INSTRUCTION MANUAL

REGULATED POWER SUPPLIES

MODELS LK-350 — LK-352

BEARING SERIAL NO.

PREFIXES A-C

MP MASTER
MA28703

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LAMBDA ELECTRONICS MELVILLE, L. I., N. Y.

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FOR

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CAT. .2855, XXX

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This manual provides instructions intended for the operation of Lambda power supplies, and is not to be reproduced without the written consent of Lambda Electronics. All information contained herein applies to all metered and non-metered models unless otherwise specified.

LAMBDA ELECTRONICS MELVILLE, L.I., N.Y.
MAIN PLANT TELEPHONE: 516 MYrtle 4-4200

IM LK35

TABLE OF CONTENTS

Section	Page
SPECIFICATIONS AND FEATURES	1
THEORY OF OPERATION	5
OPERATING INSTRUCTIONS	8
Controls, Instruments and Fuses	8
Ground Connections	9
Basic Modes of Operation	9
Supply-Load Connections	9
Detailed Operating Procedures	11
Operation After Protective Device Shutdown	15
MAINTENANCE	16
General	16
Trouble Analysis	16
Checking Transistors and Capacitors	16
Printed Circuit Board Maintenance Techniques	16
Trouble Chart	17
Adjustment of Calibration Controls	20
Adjustment of OV ADJ Control OV-R1	22
Performance Checks	23
SERVICE	24
PARTS ORDERING	24
PARTS LIST	LK-1

SPECIFICATIONS AND FEATURES

The following specifications apply for all non-metered and metered LK full-rack models.

DC OUTPUT--Voltage regulated for line and load

Voltage Range .....

TABLE I
VOLTAGE RANGE

MODEL	LK-350	LK-351	LK-352
VOLTAGE RANGE VDC	0-20	0-36	0-60

Multi-Current Ranges . . . . . Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range with input frequency 57-63 Hz. Derate current 10% for 50 Hz input frequency.

TABLE II
CURRENT RANGE

MODEL	CURRENT RANGE AT AMBIENT OF:			
	40°C	50°C	60°C	71°C
LK-350	0-35A	0-31A	0-26A	0-20A
LK-351	0-25A	0-23A	0-20A	0-15A
LK-352	0-15A	0-14A	0-12.5A	0-10A

REGULATED VOLTAGE OUTPUT

Regulation (line) . . . . . 0.015 percent or 1.0 millivolt, whichever is greater for input variations from 105-132 or 132-105 volts AC

Regulation (load) . . . . . 0.015 percent or 1.0 millivolt, whichever is greater for load variations from 0 to full load or full load to 0

Remote Programming

External Resistor . . . . . Nominal 200 ohms/volt output

Programming Voltage . . . . . One-to-one voltage change

Ripple and Noise. . . . . 0.5 millivolts rms with either positive or negative terminal grounded

Temperature Coefficient . . . . . Change in output voltage less than 0.015%/^{o}C

DC OUTPUT--Current regulated for line and load; automatic crossover with voltage limit

Multi-Current Ranges . . . . . Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range. For maximum current range see Table II. Minimum current 5% of 40^{o} rating in Table II.

Voltage Range . . . . . For voltage range see Table I; voltage ratings apply for entire current range.

REGULATED CURRENT OUTPUT; AUTOMATIC CROSSOVER

Regulation (line). . . . . Less than 10 milliamperes or 0.1%, whichever is greater, for input variations from 105-132 or 132-105 volts AC

Regulation (load). . . . . Less than 10 milliamperes or 0.1%, whichever is greater, for load voltage changes from 0 to rated VDC or rated VDC to 0 volts.

AC INPUT--105-132 volts AC at 57-63 Hz; for input power see Table III. Ratings apply for 57-63 Hz; for other input frequencies consult factory.

TABLE III

INPUT POWER, WATTS*

INPUT POWER	MODEL
1250 w	LK 350
1560 w	LK 351
1500 w	LK 352

*With output loaded to full 40^{o}C rating and input voltage 132 volts at 57-63 Hz.

OVERLOAD PROTECTION

Thermal . . . . . Thermostat, resets automatically when over-temperature condition is eliminated; Circuit breaker S1 must be manually reset to ON position to apply input power.

Electrical

External Overload Protection . . .	Adjustable, automatic, electronic current-limiting circuit, settable to 105 percent of rated current; limits output current to preset limit for protection of load and power supply when external overloads and short circuits occur
Internal	"SLO-BLO" 30A fuse F1 protects the AC input circuit. Overload of the supply does not cause fuse failure.

INPUT AND OUTPUT CONNECTIONS--Heavy duty terminal block on rear of chassis.

OVERSHOOT - No overshoot of output voltage under conditions of power turn-on, power turn-off, or power failure.

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE--Continuous duty from $0^{o}C$ to $71^{o}C$ ambient with corresponding load current ratings for all modes of operation

STORAGE TEMPERATURE- $-55^{o}C$ to $+85^{o}C$ (non-operating)

METERS-Voltmeter and ammeter on metered suffix (FM) models

CONTROLS

DC output controls	Coarse and fine voltage controls and coarse and fine current controls permit adjustment of DC output; located on front panel of all models
Remote Sensing	Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation
Power	Panel mounted circuit breaker and indicator light for all units. The circuit breaker controls application of input power to the supply. On units with "OV" option, over-voltage condition causes the breaker to trip. When breaker is in the ON position the red ON indicator lamp glows.

PHYSICAL DATA

Size	5-1/4"H x 19"W x 16-1/2"D

Weight	95 lbs. net; 125 lbs. shipping wt.
Panel Finish	Brushed aluminum clear anodized panels with grey inlay (standard); special finishes available to customer's specifications at moderate surcharge.

MOUNTING

Laboratory bench, table top	Bumpers secured to the base of all LK models permit proper circulation of air through the unit. Removal of bumpers will restrict free-flow of air through the unit; avoid removing bumpers.

Standard 19" rack mounting

MODEL OPTIONS

Suffix "OV" Overvoltage Protection Option. All LK power supplies are available with a built-in overvoltage protection circuit which prevents damage to the load that can be caused by excessive power supply output voltage.

Suffix "V" Input Option	Standard LK power supplies can be obtained for operation with 205-265 volt 47-63 Hz input or 187-242 volt, 47-63 Hz input. See nameplate for AC input rating. See schematic diagram for rewiring of AC input. For 47-57 Hz derate current 10%.
Suffix "R" Fungus Proofing Option .	Standard LK power supplies can be obtained with fungus proofing treatment with MIL V 173 varnish for all fungi nutrient components.
Suffix "FM" Meter Option	Standard LK power supplies can be obtained with voltmeter and ammeter.

THEORY OF OPERATION

GENERAL

The Lambda power supply consists of an AC input circuit and transformer; a pre-regulator circuit consisting of rectifiers, SCR(s) and filters; a preregulator control circuit containing auxiliary rectifiers and filters, a ramp generator; a ramp gate, a comparator, a reference zener and an SCR gate trigger generator; a series regulator control circuit containing a reference supply circuit consisting of rectifier, filter, prereference zener and reference zener, in addition to a 1st emitter-follower driver, a constant current generator, a current regulator comparator, a voltage-current amplifier, a voltage regulator comparator and an output sensing divider; a main regulator circuit consisting of a series regulator, the 2nd emitter-follower driver and a constant current pre-load; a drive supply consisting of rectifiers and filter.

The circuit arrangement is shown in block diagram form in figure 9. The circuitry is discussed with reference to the block diagram and the schematic diagram.

FUNCTIONAL DESCRIPTION

Single phase input power is applied to transformer T1 through the input circuit containing circuit breaker S1 and fuse F1, which protect the supply against overheating and internal faults respectively.

The pre-regulator, an SCR-type regulator and rectifier, contains the full-wave main rectifier that provides the power which is filtered by the capacitors and then regulated via a series regulator and delivered to the output. The full-wave auxiliary rectifier CR111-CR114 provides voltage filtered by capacitors C111, C112 for ramp generator Q131 comparator Q151, and SCR gate trigger generator Q171 as well as for reference zener diode CR151. The reference supply half-wave output from CR275 is filtered by capacitor C271 and converted into a constant current by a circuit comprised of transistor Q271, resistor R278 and zener diode regulator CR274. Prereference zener diode CR273 converts the reference supply output into a constant voltage to further regulate the current through reference zener CR271. The difference in voltage between diodes CR273 and CR271 is used as a reference voltage for constant current generator Q253, which sets the reference current for current controls R302A, B. The reference supply also provides regulated B+ voltage for current regulator comparator Q251, Q252, amplifier Q231 and voltage regulator comparator Q211, Q212. Auxiliary drive supply CR310, CR311, a full-wave rectifier, provides voltage filtered by C314 for drivers Q232 and Q302.

The function of the preregulator control circuit is to regulate the voltage across the series regulator transistors at some constant value regardless of line voltage and/or output voltage variation. Constant current source Q131 charges capacitor C131, which is in turn discharged at the end of each half-cycle of input power by ramp gate Q132, resulting in a repetitive ramp signal. The series regulator transistor voltage is compared with the ramp signal, the voltage reference CR151 and an SCR frequency balancing signal by comparator Q151 and the output is used to control SCR gate trigger generator Q171. The balancing signal is sensed at the anode(s) of the SCR(s) through diodes CR172 (CR174) and the associated R-C network. When a trigger signal is generated by Q171, the SCR gate is triggered on, turning on SCR301 and transferring AC power from the main secondary

windings of T1 to DC power in the filter capacitors. For units with two SCR's, each SCR functions only on every half cycle of input power instead of on each half cycle as is the case with single SCR units.

Constant current pre-load Q301 provides a path for the series-regulator transistor leakage current, regardless of variation in output voltage and input line voltage. Diode CR301 is used to provide collector voltage for C.C. pre-load Q301 when output voltage is at zero.

Constant voltage circuit operation is determined by changes in the output voltage. A change in output voltage is sensed by sensing divider R301A, B, R271, R272, which has a fixed current flowing in the divider elements, as determined by the setting of calibration control R272. This variation in output is compared with the reference voltage of zener CR271 which results in an error voltage at the junction of R301B and R272. The error voltage is amplified by voltage regulator comparator Q211, Q212, further amplified by amplifier Q231 and is current amplified by emitter-follower drivers Q232 and Q302.

In constant voltage operation the voltage across the emitter resistors is less than the preset voltage across R302A, B; Q251 is in saturation, CR232 is at cutoff; and CR231 is conducting. If the load current decreases, causing a rise in output voltage, Q211 conducts less, Q212 is biased toward cutoff and more current flows through diode CR231 instead of Q212. This action causes amplifier Q231 to conduct more heavily, reducing drive current to emitter-follower drivers Q232, Q302, causing the series regulator impedance to increase and the output voltage to decrease accordingly.

Simultaneously, Q252 of the current regulator comparator samples load current through the series-regulator emitter resistor and compares it with the preset voltage across CURRENT LIMITER resistors R302A, B that is produced by current control generator Q253. Constant voltage mode of operation automatically changes to constant current mode of operation when the output current increases and equals the pre-set current limit level. The upper limit is determined by calibration control R255. An increase in output current causes the voltage drop across the emitter resistors to equal the preset voltage across resistors R302A, B, a primary condition during constant current operation. In addition Q251 is now biased toward cutoff and current flows through zener diode CR232, causing Q231 to conduct more heavily, reducing drive current to Q232 and Q302, causing the series regulator impedance to increase and the output voltage to decrease accordingly, effectively maintaining a constant current. This output voltage decrease, sensed by the voltage sensing divider, causes turn-on of Q212 until saturation occurs and diode CR231 stops conducting. The unit now continues to function in the constant current mode of operation with zener diode CR232 controlling the turn-on bias of amplifier Q231, which in turn controls the drive current to the series regulator and ultimately the output voltage of the supply. Zener diode CR232 is also used to offset DC power line voltage drops which occur when operating the unit with remote sensing.

OVERVOLTAGE PROTECTOR CIRCUIT, FUNCTIONAL DESCRIPTION

Divider network OV-R1, OV-R2, OV-R3, OV-R4 and OV-R7 monitors the power supply output voltage. CR1, CR2, and C3 provide filtered bias voltage for coil of S1 and the anode of SCR1. R333 limits the C3 peak surge current through SCR1. When the power supply output voltage increases above the overvoltage limit set by OV ADJ control OV-R1, the voltage of the divider network also increases, biasing transistor OV-Q1 on. OV-Q1, in turn, biases OV-Q2 on through resistor OV-R10. OV-Q2 supplies gate current to OV-

SCR-1, turning it on, driving current through the breaker trip coil and into the gate of SCR-71, turning SCR-71 on. This, in turn, causes the voltage at the power supply terminals to drop, protecting the load from excessive supply output voltage. OV-SCR-1 and SCR-71 conduct until the circuit breaker trips, causing power to the power supply to be cut off.

CAUTION

The overvoltage protector circuit will not provide protection against overvoltage conditions caused by storage batteries or other power sources used in conjunction with the Lambda power supply. Whenever additional power sources must be used with the Lambda power supply and overvoltage protector combination, consult the factory for proper installation information.

OPERATING INSTRUCTIONS

CONTROLS, INSTRUMENTS AND FUSES

ON-OFF Circuit Breaker. The ON-OFF circuit breaker, located on the front panel, controls application of input power to the supply. When the switch is in the ON position, the red indicator glows.

OUTPUT VOLTAGE Control. The OUTPUT VOLTAGE control is a dual control consisting of a coarse adjustment potentiometer, which varies the DC voltage over a range 0-19, 0-35 or 0-59 volts, as applicable, and a fine adjustment potentiometer, which varies the DC voltage over a one-volt range. Clockwise rotation results in increasing voltage. The total DC voltage output for voltage regulated operation, is equal to the sum of each shaft setting; for current regulated operation the maximum voltage limit is equal to the sum of each shaft setting. The control is located on the front panel of all units.

CURRENT LIMITER Control. The CURRENT LIMITER control is a dual control consisting of a coarse adjustment potentiometer, which varies the DC current over 90% of the rated current range and a fine adjustment potentiometer, which varies the DC current over 10% of the rated current range. Clockwise rotation results in increasing current. The total DC current output for current regulated operation, is equal to the sum of each shaft setting; for voltage regulated operation the maximum current limit is equal to the sum of each shaft setting. The control is located on the front panel of all units.

Output Voltage Meter. A DC voltmeter monitors the voltage at the output terminals of metered (FM) units for the rated voltage range.

Output Current Meter. A DC ammeter monitors the load output current of metered (FM) units for the rated current range.

Fuse. Fuse F1, internally located, is a 30 ampere, 3AG "SLO-BLO" fuse which functions in the AC input circuit.

Connection Terminals. Make all connections to the supply at the terminal block on the rear of the supply. Apply input power directly to terminals 1 and 2. Always connect the ungrounded (hot) power lead to terminal 1.

The supply positive terminal is brought out to terminal 6. The supply negative terminal is brought out to terminal 4. Recommended wiring of the power supply to the load and selection of wiring is shown in figures 1 through 8. Selection of proper wiring is made on the basis of load requirements. Make all performance checks and measurements of current or voltage at the rear output terminals. Connect measuring devices directly to terminals or use the shortest leads possible.

OV ADJ Control. This potentiometer is only used on units with the "OV" Overvoltage Protector option. The OV ADJ control permits screwdriver setting of the overvoltage protection point through an access hole in the front panel.

GROUND CONNECTIONS

The Lambda power supply can be operated either with negative or positive output terminal grounded or with no terminal grounded. Both positive and negative ground connections are shown in the diagrams for all suggested output connections illustrated in this manual.

> NOTE: When operating the supply with neither terminal grounded, high impedance leakage resistance and capacitance paths can exist between the power supply circuitry and chassis ground.

BASIC MODES OF OPERATION

This power supply is designed to operate as a constant voltage source or as a constant current source. Automatic crossover to either mode of operation occurs when load conditions change as follows:

Constant Voltage. The power supply will function as a constant voltage source while the load current does not equal the current value, I_{LIM}, set by the CURRENT LIMITER control. When load current $I_L = \frac{V}{R_L} = I_{LIM}$, the supply will cross over automatically and will operate as a constant current source. Further decrease in value of load resistance R_L results in decrease of voltage across the load while current remains regulated to I_{LIM}.

Constant Current (Automatic Crossover). The power supply will function as a constant current source while the load voltage V_L does not equal the voltage value set by the OUTPUT VOLTAGE control. When load voltage V_L equals the value set by the OUTPUT VOLTAGE control, the supply will automatically cross over and operate as a constant voltage source.

SUPPLY-LOAD CONNECTIONS

> NOTE: Refer to DETAILED OPERATING PROCEDURES for step-by-step instructions for operation of power supply.

CONNECTIONS FOR OPERATION AS A CONSTANT VOLTAGE SOURCE

The regulation of the power supply at the load may change when using the supply as a constant voltage source and connecting leads of practical length are used. To minimize the effect of the output leads on this characteristic, remote sensing is used. Recommended types of supply-load connections with local or remote sensing are described in the following paragraphs.

Refer to figure 1 to determine voltage drop for particular cable length, wire size and current conditions. Lead lengths must be measured from supply terminals to load terminals as shown in figure 2.

Two-Wire Connection, Figure 3. The two-wire connection with local sensing, provides simplest connection suitable for applications with relatively constant load.

Four-Wire Connection, Figure 4. The four-wire connection with remote sensing, provides complete compensation for the DC voltage drops in the connecting cables. Compensation for lead drop is also valid for gradual changes of load current. Sensing leads should be a twisted pair to minimize AC pick-up. A 2.5 mf, elect., capacitor may be required between output terminals and sense terminals to reduce noise pick-up.

Programmed Voltage Connections, Using External Resistor, Figure 5. Discrete voltage steps can be programmed with a resistance voltage divider valued at 200 ohms/ volt output and a shorting-type switch as shown in figure 5. When continuous voltage variations are required, use a variable resistor with the same 200 ohms/volt ratio in place of the resistive voltage divider and shorting-type switch. Use a low temperature coefficient resistor to assure most stable operation.

As shown in figure 5, voltages can be programmed utilizing either local or remote sensing connections, as desired.

Programmed Voltage Connections Using Programming Voltage, Figure 6. The power supply output voltage can be programmed with an externally connected programming power supply. The output voltage of the programmed supply will maintain a one-to-one ratio with the voltage of the programming supply.

The programming supply must have a reverse current capability of 6 ma. minimum.

Alternatively, when supplies with less than 6 ma. reverse current capability are used, a resistor capable of drawing 6 ma. at the minimum programming voltage must be connected across the output terminals of the supply. This programming supply must be rated to handle all excess resistor current at the maximum programming voltage.

CONNECTIONS FOR OPERATION AS A CONSTANT CURRENT SOURCE

Automatic Crossover Constant Current Connections, Figure 3. Figure 3 shows the connections which are used when operating the power supply as a constant current source with automatic crossover, using local setting of current control.

In this mode of operation, when the load voltage increases, due to changing load resistance, to the limit of the OUTPUT VOLTAGE control setting, the power supply crossover circuit will cause the unit to operate as a constant voltage supply.

CONNECTIONS FOR SERIES OPERATION

The voltage capability of LK power supplies can be extended by series operation of LK power supplies of equal or unequal voltage ratings. A maximum of 200 volts can be connected between either the +DC or -DC terminal and chassis ground.

Two units are shown connected for series operation in figure 7. Figure 7 shows the series connection diagram which would be suitable for use in all applications.

Diodes CR_A and CR_B, which protect the units against reverse voltage, must be capable of withstanding the maximum rated current.

The series connection permits operation for either constant voltage or constant current with automatic crossover to either mode of operation whenever the respective limiting operating current or voltage is reached. Figure 7 shows connection for either local or remote sensing, when the series combination is operated for constant voltage; figure 7a shows the connection required when the series combination is operated for constant current.

CONNECTIONS FOR PARALLEL OPERATION

The current capability of LK power supplies can be extended by parallel operation of two LK power supplies of equal* voltage capacities. The two units are shown connected for parallel operation in figure 8. One power supply designated the (M) unit controls its own output as well as the output of the second power supply, designated the (S) unit.

Unit (S) operates to regulate its current in a ratio to that of the (M) unit by comparing the current in its internal sampling resistor with that current sampled by the master internal sampling resistor. When power supplies of unequal current capacities are parallel connected the division of current supplied will be approximately equal to the ratio of the current ratings of the supplies.

Parallel connected units can be operated for constant voltage with local sensing as well as for constant current with automatic crossover. When operating for constant voltage, the (M) unit can automatically cross over into constant current operation.

*For applications using supplies of unequal voltage ratings, consult factory for details of operation.

DETAILED OPERATING PROCEDURES

SAFETY NOTICE

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT. OBSERVE THE USUAL SAFETY PRECAUTIONS WHEN OPERATING OR SERVICING THE EQUIPMENT TO AVOID SHOCK OR INJURY.

CONSTANT VOLTAGE OPERATION, ADJUSTABLE CURRENT LIMIT

1. Remove AC power input to supply and place ON-OFF circuit breaker in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size from figures 1 and 2 and choose desired type of supply-load connection from figures 3 and 4.

3. Connect supply to load as shown on the selected connection diagram.

NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic crossover or as a local-sensing constant voltage source. Jumpers are connected at the factory as shown in figure 3. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

4. Turn OUTPUT VOLTAGE control knobs to the desired voltage setting.

5. When current to the load must be limited to an intermediate value within the current rating of the supply, turn the CURENT LIMITER control knobs to the desired current limit setting. If no intermediate current limit is required, turn the control knobs CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to supply.

7. Place ON-OFF circuit breaker in ON position and check that red indicator is lit.

8. Check that output current and output voltage meters indicate desired values; as required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control knobs to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 6 and 4; for remote sensing connections, check at the load terminations of sensing leads on terminals 3 and 7.

9. Power supply is now in proper operation.

PROGRAMMED CONSTANT VOLTAGE OPERATION, ADJUSTABLE CURRENT LIMIT

1. Remove AC power input to the supply and place ON-OFF circuit breaker in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size and length from figures 1 and 2. Choose desired type of supply-load connection from figures 5 or 6. Refer to paragraph on Programmed Voltage Connections.

3. Connect supply to load as shown on the selected connection diagram. As shown in figure 5, take care to use a shorting-type switch for the external programming control when several voltages are desired and the programming voltage method is not used.

4. Turn OUTPUT VOLTAGE control knobs to the extreme CCW position. Adjust external programming voltage control to desired voltage setting.

5. When current to the load must be limited to an intermediate value within the current rating of the supply, turn the CURRENT LIMITER control knobs to the desired current limit setting. If no intermediate current limit is desired, turn the control knobs CW to the position for full rated current for the ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to the supply.

7. Place ON-OFF circuit breaker in ON position and check that red indicator is lit.

8. Check that output current and output voltage meters indicate desired values; as required, adjust CURRENT LIMITER knobs and external programming voltage control to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6; for remote sensing connections, check at the load terminations of sensing leads on terminals 3 and 7.

9. Power supply is now operating properly.

CONSTANT CURRENT OPERATION WITH CROSSOVER, ADJUSTABLE VOLTAGE LIMIT

1. Remove AC power input to the supply and place ON-OFF circuit breaker in OFF position before connecting load to the supply.

2. Determine load requirements and connect load to the supply as shown in figure 3.

3. Turn the CURRENT LIMITER knobs to the desired current settings.

4. When load voltage must be limited to an intermediate value within the voltage rating of the supply, turn OUTPUT VOLTAGE control knobs to the desired voltage limit setting. If no intermediate voltage limit, within rating of supply is desired, turn control knobs to the full CW position to obtain voltage limit at maximum voltage rating of the supply.

5. Apply AC power to the supply.

6. Place ON-OFF circuit breaker in ON position and check that red indicator is lit.

7. Check that output current and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control knobs as required to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6.

8. Power supply is now in proper operation.

SERIES CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to the (B) and (A) units and place ON-OFF circuit breakers in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 and choose correct type of series supply-load connections from figure 7. Refer to paragraph on Connections for Series Operation.

3. Connect supply to load as shown on the selected connection diagram. As required, select diodes CR_A and CR_B in accordance with instructions contained in Connections for Series Operation.

4. Turn (A) and (B) unit OUTPUT VOLTAGE control knobs to the desired total voltage setting.

5. When current to the load must be limited to an intermediate value within current rating of the units, turn each CURRENT LIMITER control knob to the desired setting. If no intermediate current limit is required, turn the control knobs of each unit CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on specifications.

> NOTE: When units of unequal current rating are series connected, the unit with the lower current rating must be capable of delivering the desired load current.

6. Apply AC power to the supplies.

7. Place ON-OFF circuit breakers of both units in ON position and check that red indicators are lit.

8. Check that output current and output voltage meters indicate desired values; total voltage is equal to sum of (A) and (B) units. As required, adjust OUTPUT VOLTAGE control knobs of both units to obtain correct indication; overload supply and adjust CURRENT LIMITER control knobs of both units to obtain correct indication. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals of both units; positive (+) terminal of (A) unit and minus (-) terminal of the (B) unit are the output terminals of the series combination.

For remote sensing connection, make checks at the load terminations of sensing leads from terminal 7 of (A) and from terminal 3 connection of (B) unit.

9. Power supplies are now in proper operation.

PARALLEL CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to each supply and place ON-OFF circuit breaker on both (M) and (S) units in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1 and 2 in the manual. Refer to paragraph on Connections for Parallel Operation.

3. Connect supplies to load as shown in connection diagram, figure 8.

> NOTE: When shipped from the factory, each supply is ready for use as a constant current source or as a local-sensing constant voltage source. Jumpers are connected at the factory. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

4. Turn OUTPUT VOLTAGE control knobs on the (M) unit to the desired voltage setting, and turn the OUTPUT VOLTAGE control knobs on the (S) unit to fully CCW position.

5. When current to the load must be limited to an intermediate point, turn the CURRENT LIMITER control knobs on both the (M) and (S) units to the desired current limit setting. Set current limit control on the (M) and (S) units to the position indicating the current value to be delivered by the respective unit. If no intermediate current limit is desired, turn the CURRENT LIMITER control knobs CW on both (M) and (S) units to the position for full rated current for the maximum ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to each supply.

7. Place ON-OFF circuit breakers on (M) and (S) units in ON position and check that red indicators are lit.

8. Check that output current and output voltage meters on both (M) and (S) units indicate desired values; as required, adjust OUTPUT VOLTAGE control and CURRENT LIMITER CONTROL on (M) unit to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6 of the (M) unit.

9. Power supplies are now in proper operation.

OPERATION AFTER PROTECTIVE DEVICE SHUTDOWN

Thermostat Shutdown

The thermostat causes the circuit breaker to open the input circuit only when the temperature of the transistor heat radiator exceeds a maximum safe value. The thermostat will automatically reset when the temperature of the radiator decreases to safe operating value. After eliminating the cause(s) for overheating and allowing time for the power supply to cool to a proper temperature, place ON-OFF circuit breaker in the ON position and resume operation of the supply. Refer to appropiate operation paragraph in DETAILED OPERATION PROCEDURE.

Fuse Shutdown

Internal failure of supply causes the fuse to clear the circuit, removing input power from the supply. Overloading of the unit will not cause fuse failure. Fuses will blow when the maximum rated current value for the fuse is exceeded. Fatigue failure of fuses can occur when mechanical vibrations from the installation combine with thermally induced stresses to weaken the fuse metal. Many fuse failures are caused by a temporary condition and replacing the blown fuse will make the fuse protected circuit operative.

Circuit-Breaker Shutdown (For "OV" Suffix Models)

The ON-OFF circuit breaker controls application of input power to all Model LK power supplies with built in overvoltage protection. When the power supply output voltage increases above the preset overvoltage limit, the breaker trips, opening the input circuit, causing the ON-OFF indicator to extinguish. After eliminating the cause(s) for overvoltage, resume operation of the supply by placing circuit breaker in ON position.

MAINTENANCE

GENERAL

This section describes trouble analysis routine, replacement procedures, calibration and test procedures that are useful for servicing the Lambda power supply. Refer to the section on specifications and features for the minimum performance standards.

TROUBLE ANALYSIS

Whenever trouble occurs, systematically check all fuses, primary power lines, external circuit elements, and external wiring for malfunctions before trouble shooting the equipment. Failures and malfunctions often can be traced to simple causes such as improper jumper and supply-load connections or fuse failure due to metal fatigue.

Use the electrical schematic diagram and block diagram, figure 9, as an aid to locating trouble causes. The schematic diagram contains various circuit voltages that are averages for normal no-load operation. Measure these voltages using the conditions for measurement specified on the schematic diagram. Use measuring probes carefully to avoid causing short circuits and damaging circuit components.

CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an in-circuit transistor checker. If no checker is available, transistors can be checked with an ohmmeter that has a highly limited current capability. Observe proper polarity for PNP or NPN to avoid error in measurement. The forward transistor resistance is low but never zero; backward resistance is always higher than the forward resistance.

Do not assume trouble is eliminated when only one part is replaced. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning power on, before checking for additional defective components could damage the replaced component.

When soldering semi-conductor devices, hold the lead being soldered with a pair of pliers placed between the component and the solder joint to provide an effective heat sink.

> NOTE: The leakage resistance obtained from a simple resistance check of a capacitor is not always an indication of a faulty capacitor. In most cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

PRINTED CIRCUIT BOARD MAINTENANCE TECHNIQUES

1. If foil is intact but not covered with solder it is a good contact. Do not attempt to cover with solder.

2. Voltage measurements can be made from either side of the board. Use a needle-point probe to penetrate to the wiring whenever a protective coating is used on the wiring. A brass probe can be soldered to an alligator clip adapted to measuring instrument.

3. Always use a heat sink when soldering transistors; a transistor pad with mounting feet is an effective heat sink.

4. Broken or damaged printed wiring is usually the result of an imperfection, strain or careless soldering. To repair small breaks, tin a short piece of hook-up wire to bridge the break, and holding the wire in place, flow solder along the length of wire so that it becomes part of the circuitry.

5. When unsoldering components from the board never pry or force loose the part; unsolder the component by using the wicking process described below:

(a) Select a 3/16 inch tinned copper braid for use as a wick; if braid is not available, select AWG No. 14 or No. 16 stranded wire with 1/2 inch insulation removed.

(b) Dip the wick in liquid rosin flux.

(c) Place the wick onto the soldered connection and apply soldering iron onto the wick.

(d) When sufficient amount of solder flows onto the wick, freeing the component, simultaneously remove iron and wick.

TROUBLE CHART

The trouble chart is intended as a guide for locating trouble causes, and is used along with the schematic diagram.

The operating conditions assumed for the trouble chart are as follows:

(a) AC power of proper voltage and frequency is present at input terminals.

(b) Either positive or negative terminal is connected to chassis ground.

(c) The power supply is connected for constant voltage with local sensing. See schematic; dotted lines indicate jumpers connected for local sensing operation.

TROUBLE CHART

Symptom	Probable Cause	Remedy
1. Power ON-OFF lamp DSI does not light with ON-OFF breaker in ON position; no output voltage; breaker cannot be set to ON	No power input; ON-OFF breaker S1 defective; defective fuse F1; fuse F1 blown; thermostat S2 closed	Check power source, line cord and line plug; replace S1, replace F1; shut off unit, allow to cool and check ambient temperature
		Replace F1; if it blows immediately, as applicable, check diodes CR305, CR306 (CR307, CR308) for shorts, SCR301 (SCR302) C305 — C309 for shorts; replace as necessary
2. Unable to adjust output voltage	Damaged OUTPUT VOLTAGE controls	Check R301 A, B for shorts and/or open; replace as necessary
	Supply operating as constant current source with crossover at CURRENT LIMITER setting	Remove load and check for shorts and/or improper supply-load connections; refer to appropriate diagram for correct connections
	On OV units faulty SCR71 (least probable cause)	On OV units check for faulty SCR 71 (See step 8)
3. Zero volts DC output, with ON-OFF indicator DS1 lit	OUTPUT VOLTAGE controls turned fully CCW	Check OUTPUT VOLTAGE controls for proper setting and correct as necessary
	Short circuit across output of supply	Check load and load connections; correct as required
	Rectifiers CR305, CR306 (CR307, CR308) open, SCR301, (SCR302) open or gate of SCR(s) open or shorted	Check and replace as required
	Q151, Q171, CR111- CR114 open; CR151 C111 shorted	Check and replace as required
	C.C. pre-load Q301 shorted; Q302, CR301 open	Check and replace as required

Symptom	Probable Cause	Remedy
	Q211 shorted, Q212 open; Q231 shorted; Q232 open; Q251 open, Q252 shorted; CR232 shorted; R272 open	Check and replace as required
4. Output voltage too high	Improper output terminal connection	Refer to appropriate connection diagram and check for correct connections
On OV units, breaker trips and cannot be reset	Improper adjustment of OV ADJ control	Refer to procedure for adjusting OV ADJ control and reset control
	2nd driver Q302 and series regulator transistors shorted; Q211 open, Q212 shorted ; Q231 open; Q232 shorted; CR271 open	Check appropriate component and replace as necessary
	OV-Q1, OV-Q2, OV-SCR-1 on OV subassembly faulty (least probable fault cause)	Check OV-Q1, OV-Q2, OV-SCR-1 for short and replace as required
5. Output intermittant or no output	Circiut breaker S1 activiated by thermostat S2 caused by high temperature condition at series regulator transistor mounting	Check output current setting for agreement with rating at ambient temperature and adjust accordingly
6. High ripple at line frequency or twice line frequency and high unregulated DC output	2nd driver Q302 and series regulator transistors shorted; Q211 open, Q212 shorted; Q231 open; Q232 shorted; CR271 open	Check appropriate component and replace as necessary
	Defective main rectifier causes ripple at twice line frequency	Check CR305, CR306, CR307, CR308 in addition to Q302-Q308 and Q231 and replace as necessary
7. Low unregulated DC output with high ripple	Line voltage too low	Check and correct AC input voltage at supply terminals
	Rectifier CR310 or CR 311 faulty; filter C314 faulty; series regulator transistors have low gain	Check CR310 CR311 for open and replace as required; check that voltage across R329 is 3.0 volts max.

8. Low unregulated DC output with low ripple	CURRENT LIMITER controls improperly adjusted	Check current setting on unit and adjust current controls for correct indication
	Load resistance incorrect for unit rating	Check value of load resistance for compatibility with power supply ratings
	CURRENT LIMITER controls R302 A,B defective	Check and replace R302 A, B as required
Output voltage too low on units with OV option	Faulty SCR71 in OV circuit (least probable fault cause)	Remove cathode connection to SCR71 and reapply power, if output is restored, SCR71 is faulty; replace SCR71
9. Regulation is poor when operating in constant current mode	Insufficient voltage compliance	Refer to appropriate procedure for constant current operation and adjust OUTPUT VOLTAGE controls for correct indication
10. Large spikes evident at output	Capacitor C311 open	Check and replace C311 as required
11. High ripple	Improper ground connection	Connect terminal 4 or terminal 6 to ground terminal 5

ADJUSTMENT OF CALIBRATION CONTROLS

Whenever parts are replaced, adjust calibration controls only when voltage and current indications are improper and do not reflect maximum rating.

Adjustment Maximum Output Voltage Set Control R272 as Follows

1. Remove AC power input to the supply and place ON-OFF circuit breaker in OFF position.

2. Unsolder wiper of R272 from resistor housing.

3. Operate the power supply for constant voltage with local-sensing jumpers connected as shown in figure 3, and no external load.

4. Turn OUTPUT VOLTAGE control knobs fully clockwise, and, using a DC voltmeter of 0.1 percent accuracy or better, adjust R272 to provide output voltage E_O MAX + 0.20 volts; where E_O MAX is the rated output voltage of the supply.

5. After adjustment is completed, remove AC power input to the supply and solder wiper of R272 to potentiometer housing.

Adjust Maximum Output Current Set Control R255 as Follows:

1. Remove AC power input to the supply and place ON-OFF circuit breaker in OFF position.

2. Unsolder wiper of R255 from resistor housing.

3. Turn OUTPUT VOLTAGE control knobs and CURRENT LIMITER control fully CW.

4. Operate the power supply for constant current crossover, connected as shown in figure 3, with a short circuit across the output terminals.

5. Adjust R255 for 105% of rated current output at 40°C ambient, using any DC ammeter of one percent accuracy or better.

6. After adjustment is completed, remove AC power input to the supply and solder wiper of R255 to potentiometer housing.

Adjust Series Regulator Voltage Set Control R152 as Follows:

1. Remove AC power input to the supply and place ON-OFF circuit breaker in OFF position.

2. Unsolder wiper of R152 from resistor housing.

3. Turn OUTPUT VOLTAGE control knobs and CURRENT LIMITER control knobs fully CW.

4. Connect DC voltmeter of one percent accuracy or better, between output terminal 6 and positive terminal of filter capacitor C305.

5. Connect power supply for constant voltage operation with local sensing jumpers connected as shown in figure 3.

6. Connect resistive load. Calculate load value as follows:

$$R\ LOAD = \frac{E_{MAX}}{I_{MAX} \text{ at } 40^{\circ}C}$$

7. Provide AC input power of 132 VAC to supply and place ON-OFF circuit breaker in ON position.

8. Adjust R152 until voltmeter indicates applicable voltage listed here for the appropriate LK model.

MODEL	VOLTMETER INDICATION
LK350	7.0 VDC
LK351	8.5 VDC
LK352	12.0 VDC

ADJUSTMENT OF OV ADJ CONTROL OV-R1

Adjust the voltage-protection point of overvoltage protector circuit as follows:

1. Turn OV ADJ control on front panel fully clockwise.

2. The recommended voltage-protection point is 115% of normal power supply operation voltage plus one volt. Compute this value for the operation voltage being used.

3. Turn on the power supply, and raise the output voltage to the desired voltage-protection point; monitor the power supply output voltage to assure correct voltage. If the power supply does not have an adequate adjustment range omit steps 4 and 5, and continue with step 6 below.

4. Slowly turn the OV ADJ control counterclockwise until the circuit breaker trips, indicating that the voltage protection point is reached.

5. The voltage-protection point is now set. Reduce power supply output voltage setting before re-applying input power.

6. If the power supply output voltage adjustment range does not extend to the protection-point voltage computed in step 2, proceed as follows:

   a) Turn on power supply and raise output voltage to the normal operating voltage, taking care to monitor the power supply output voltage.

   b) Slowly turn the OV ADJ control counterclockwise until the circuit breaker trips.

   c) Refer to chart below, select appropriate volts/turn ratio, and turn OV ADJ control clockwise by the number of turns equivalent to 1 volt plus 15% of the operating voltage.

MODEL	VOLTS/TURN
LK350-OV	2.3
LK351-OV	4.6
LK352-OV	6.9

For Example:

When using power supply LK350-OV with output voltage setting of 20 volts, calculate as follows:

$$T = \frac{1 + .15\ (OV)}{V/T}$$

where:

T = turns of OV ADJ control

OV = operating voltage of power supply

V/T = volts/turn ratio from chart

$$T = \frac{1 + .15\,(20)}{2.3} = 1.7$$

Rotate OV ADJ control 1.7 turns in clockwise direction to obtain a voltage setting 4.0 volts above the 20-volt power supply setting, or 24.0 volts.

PERFORMANCE CHECKS

Checks With Constant Voltage Operation

Check the ripple and regulation of the power supply using the test connection diagram shown in figure 10. Use suggested test equipment or equivalent to obtain accurate results. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Set the differential meter, DC VTVM (Lambda power supply Model LS-515 with differential VM accessory Model LS-DM5 or equivalent) to the selected power supply operating voltage. Check the power supply load regulation accuracy while switching from the load to no-load condition. Long load leads should be a twisted pair to minimize AC pick-up.

Use a Variac to vary the line voltage from 105-132 or 132-105 volts AC and check the power supply line regulation accuracy on the VTVM differential meter.

Use a VTVM, Ballantine 320 or equivalent, to measure rms ripple voltage of the power supply DC output.

Checks With Constant Current Operation

Check the regulation of the power supply using the test connection diagram shown in figure 11. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Check the power supply load regulation accuracy while switching from the short circuit to load condition. Measure the voltage across sensing resistor Rs. Use Lambda power supply Model LS-515 with differential VM accessory Model LS-DM5 or equivalent for the VTVM connected across Rs. For Rs, use a resistor having value $Rs = \frac{1}{Iout}$

To obtain regulation figure, substitute values obtained into regulation formula:

$$\frac{\Delta E}{Rs} = \text{Regulation in milliamperes,}$$

where ΔE is the voltage change in millivolts and Rs is the resistance of the sensing resistor.

Use a Variac to vary the line voltage from 105-132 or 132-105 volts AC and check the power supply line regulation accuracy using VTVM and the regulation formula:

$$\frac{\Delta E}{Rs}$$

SERVICE

When additional instructions are required or repair service is desired, contact the nearest Lambda office where trained personnel and complete facilities are ready to assist you.

Please include the power supply model and serial number together with complete details of the problem. On receipt of this information, Lambda will supply service data or advise shipping for factory repair service.

All repairs not covered by the warranty will be billed at cost and an estimate forwarded for approval before work is started.

PARTS ORDERING

Standard components and special components used in Lambda power supply can be obtained from the factory. In case of emergency, critical spare parts are available through any Lambda office.

The following information must be included when ordering parts:

1. Model number and serial number of power supply and purchase date.
2. Lambda part number.
3. Description of part together with circuit designation.
4. If part is not an electronic part, or is not listed, provide a description, function, and location of the part.

PARTS LIST

The electrical parts located on Lambda models LK-350 —— LK-352 are listed here. Parts common to all models are listed first. Unique parts of individual models are listed separately, by model, immediately following the group common-parts listing. In addition there are separate listings of parts for the T option, V option, R option and the over-voltage protection (OV) option as applicable, for all models.

COMMON PARTS

MODELS LK-350—LK-352

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
C111	Cap., elect., 40 mf, (37 mf min., 75 mf max.) 35 vdc	CBP-40-014
C112	Cap., elect., 200 mf -10 + 75%,25 vdc	CBR-20-048
C131	Cap., tant., 3.3 mf ±20%, 35 vdc	CBN-33-019
C153	Cap., elect., 75 mf -10 + 100%, 55 vdc	CBP-75-009
C171	Cap., mylar, 0.1 mf ±10%, 200 vdc	CAM-10-012
C211	Cap., mylar, 0.0022 mf ±10%, 200 vdc	CGK-22-008
C212	Cap., elect., 3.0 mf -10 + 75%, 100 vdc	CBN-30-015
C231	Cap., mylar, 0.01 mf ±20%, 80 vdc	CGL-10-008
C232	Cap., mylar, 0.10 mf ±10%, 80 vdc	CGM-10-006
C251	Same as C231	
C271	Same as C153	
C272	Same as C231	
C314	Cap., elect., 3600 mf, -10 + 100%, 26 vdc	CBS-36-044
C315	Cap., mylar, 0.10 mf ±10%, 400 vdc	CGM-10-011
C318	Same as C111	
CR111 Thru CR116	Rectifier	FBL-00-030
CR131, CR132	Same as CR111	
CR152 Thru CR158	Same as CR111	
CR171, CR175, CR211, CR231	Same as CR111	
CR232	Rectifier, zener diode	FBM-Z104
CR271	Rectifier, zener diode	FBM-Z107
CR272	Same as CR111	
CR273	Rectifier, zener diode	FBM-Z115
CR274	Same as CR232	
CR275	Same as CR111	
CR303, CR304, CR309	Same as CR111	
CR310	Rectifier	FBL-00-054
CR311	Same as CR310	
DS1	Pilot lamp assembly	HRD-00-021
F1	Fuse, 30A	FFH-30-000
Q131	Transistor, NPN	FBN-L110
Q132	Transistor, PNP	FBN-L118
Q151	Same as Q132	
Q211, Q212	Transistor, dual complementary, NPN, PNP	FBN-L117

COMMON PARTS (Cont)

MODELS LK-350—LK-352 (Cont)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
Q231	Same as Q131	
Q232	Transistor, NPN	FBN-L113
Q251, Q252	Same as Q211, Q212	
Q253	Same as Q132	
Q271	Transistor, NPN	FBN-L109
Q301	Transistor, NPN	FBN-L148
Q302	Transistor, NPN	FBN-36485
R111	Res., WW, 600 ohms ±3%, 3 w	DFR-60-005
R132	Res., comp., 3,300 ohms ±10%, 1/2 w	DEB-3321
R133	Res., comp., 22,000 ohms ±10%, 1/2 w	DEB-2231
R134	Res., comp., 12 ohms ±10%, 1/2 w	DEB-1201
R152	Res., var., WW, 600 ohms ±10%, 1-1/2 w	DNR-60-012
R153	Res., comp., 470 ohms ±10%, 1/2 w	DEB-4711
R154	Res., comp., 270 ohms ±10%, 2 w	DHB-2711
R155	Res., comp., 1200 ohms ±10%, 1/2 w	DEB-1221
R156	Same as R155	
R157	Res., comp., 4700 ohms ±10%, 1/2 w	DEB-4721
R158	Res., comp., 2200 ohms ±10%, 1/2 w	DEB-2221
R159	Res., comp., 12000 ohms ±10%, 1/2 w	DEB-1231
R160	Same as R133	
R161	Same as R157	
R162	Res., comp., 1000 ohms ±10%, 1/2 w	DEB-1021
R163	Same as R133	
R164, R165	Same as R157	
R176	Res., comp., 33 ohms ±5%, 1/4 w	DCB-3305
R211	Same as R158	
R212	Same as R155	
R213	Res., comp., 33,000 ohms ±10%, 1/2 w	DEB-3331
R214	Same as R159	
R215	Same as R158	
R216	Same as R134	
R231	Same as R155	
R232	Res., comp., 10,000 ohms ±10%, 1/2 w	DEB-1031
R233	Res., comp., 390 ohms ±10%, 1/2 w	DEB-3911
R234	Res., comp., 39,000 ohms ±10%, 1/2 w	DEB-3931
R251	Res., comp., 47,000 ohms ±10%, 1/2 w	DEB-4731
R252	Res., comp., 120,000 ohms +10%, 1/2 w	DEB-1241

COMMON PARTS (Cont)

MODELS LK-350——LK-352 (Cont)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
R253	Same as R155	
R254	Same as R158	
R255	Res., var., WW 5,000 ohms ±10% 1-1/2 w	DNS-50-015
R256	Res., film, 1300 ohms ±5%, 1/2 w	DCS-13-010
R271	Res., WW, 910 ohms ±3%, 3 w	DFR-91-069
R272	Same as R152	
R273	Res., comp., 470 ohms ±5%, 1/2 w	DEB-4715
R274	Res., comp., 330 ohms ±10%, 1/2 w	DEB-3311
R276	Res., comp., 6200 ohms ±5%, 1/2 w	DEB-6225
R277	Same as R213	
R278	Res., film, 180 ohms ±5%, 1/2 w	DCR-18-019
R279	Same as R155	
R280	Res., comp., 1000 ohms ±10%, 1/4 w	DCB-1021
R302A, B	Res., var., WW two section, 500 ohms and 50 ohms, ±5% 5 w/section	DNR-55-024
R303	Same as R162	
R304	Same as R232	
R306	Res., film, 2700 ohms ±10%, 2 w	DCS-27-034
R307	Res., comp., 56 ohms ±10%, 1/2 w	DEB-5601
R310	Res., comp., 22 ohms ±10%, 1/2 w	DEB-2201
R311	Same as R153	
R312	Res., comp., 3.3 ohms ±5%, 1/2 w	DEB-33G5
R314, R316, R318, R320, R322	Same as R312	
R325	Res., comp., 120 ohms ±10%, 1/2 w	DEB-1211
R329	Res., WW, 2.0 ohms ±5%, 25 w	DFN-20-006
S1	Switch, circuitbreaker type with coil	FHC-01-001-2
S2	Thermostat	FKA-124-017
XF1	Fuseholder	HRM-00-004

UNIQUE PARTS

MODEL LK-350

C151	Cap., mylar, .0047 mf ±10%, 200 vdc	CGK-47-002
C152	Cap., mylar, .047 mf ±10%, 80 vdc	CGL-47-013
C154	Same as C151	
C172	Cap., mylar, .01 mf ±20%, 80 vdc	CGL-10-008
C302	Cap., mylar, 0.22 mf ±10%, 80 vdc	CGM-22-004
C303	Cap., elect., 14,000 mf -10 + 100%, 35 vdc	CBT-14-012
C304	Cap., elect., 150 mf -10 + 75%, 45 vdc	CBR-15-051
C305 Thru C309	Same as C303	

UNIQUE PARTS (Cont)

MODEL LK-350 (Cont)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
C311	Not assigned	
C312	Cap., mylar, 0.1 mf ±10%, 200 vdc	CAM-10-012
C313	Same as C312	
C317	Not assigned	
CR151	Rectifier, zener diode	FBM-Z112
CR172, CR174	Rectifier, semi-conductor	FBL-00-030
CR301	Rectifier, semi-conductor	FBL-00-122
CR302	Rectifier, zener diode	FBM-Z113
CR305 Thru CR308	Not assigned	
L301	Reactor, filter	BBA-350
L302	Same as L301	
M1*	Meter, volts, 0-20 vdc	EBP-20-014
M2*	Meter, amperes, 0-50 amps	EDP-50-017
Q171	Transistor, NPN	FBN-L113
Q303	Transistor, NPN	FBN-36972
Q304 Thru Q308	Same as Q303	
R131	Res., comp., 120 ohms ±10%, 1/2 w	DEB-1211
R171, R172	Res., comp., 220,000 ohms ±10%, 1/4 w	DCB-2241
R175	Not assigned	
R177	Res., comp., 33 ohms ±5%, 1/4 w	DCB-3305
R301A, B	Res., var., WW, two sections, 3800 ohms; 200 ohms; ±5%, 5 w/section	DNS-40-061
R305	Res., comp., 47 ohms ±10%, 1/2 w	DEB-4701
R308	Res., film, 2,700 ohms ±10%, 2 w	DCS-27-034
R313A, B	Res., WW, tapped, two sections, 0.18 ohms ±5%, 11 w/section	DFM-36-049
R315A, B	Same as R313A, B	
R317A, B	Same as R313A, B	
R319	Res., comp., 470 ohms ±10%, 1/2 w	DEB-4711
R324	Res., WW, 500 ohms ±3%, 7 w	DFR-50-070
R326	Same as R131	
R327	Not assigned	
R328	Not assigned	
R330*	Res., meter shunt, 50 amperes	ESP-50-002
R333	Res., WW, 4.0 ohms ±3%, 3 w	DFN-40-043
SCR301	Rectifier, silicon controlled	FBP-00-008
SCR302	Same as SCR301	
T1	Transformer	ABA-350-1
T2	Transformer	ABA-350-2

*This part used only on units with "FM" meter option

MODEL LK-351

C151	Cap., mylar, .0047 mf ±10%, 200 vdc	CGK-47-002
C152	Cap., mylar, .10 mf ±10%, 80 vdc	CGM-10-006
C154	Same as C151	

UNIQUE PARTS (Cont)

MODEL LK-351

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
C172	Cap., mylar, .01 mf ±20%, 80 vdc	CGL-10-008
C302	Cap., mylar, 0.22 mf ±10%, 80 vdc	CGM-22-004
C303	Cap., elect., 7800 mf -10 + 100%, 60 vdc	CBS-78-045
C304	Cap., elect., 150 mf -10 + 75%, 45 vdc	CBR-15-051
C305 Thru C309	Same as C303	
C311	Cap., mylar, 1.0 mf ±20%, 200 vdc	CAN-10-024
C312	Not assigned	
C313	Not assigned	
C317	Not assigned	
CR151	Rectifier, zener diode	FBM-Z112
CR172, CR174	Not assigned	
CR301	Rectifier	FBL-00-083
CR302	Rectifier, zener diode	FBM-Z114
CR305 Thru CR308	Same as CR301	
L301	Reactor, filter	BBA-351
L302	Not assigned	
M1*	Meter, volts, 0-40 vdc	EBP-40-013
M2*	Meter, amperes, 0-30 amps	EDP-30-016
Q171	Transistor, NPN	FBN-L109
Q303	Transistor, NPN	FBN-38022
Q304 Thru Q308	Same as Q303	
R131	Res., comp., 120 ohms ±10%, 1/2 w	DEB-1211
R171, R172	Res., comp., 470,000 ohms ±10%, 1/4 w	DCB-4741
R175, R177	Not assigned	
R301A, B	Res., var., WW, two sections, 7,000 ohms; 200 ohms; ±5%, 5 w/section	DNS-72-063
R305	Res., comp., 47 ohms ±10%, 1/2 w	DEB-4701
R308	Res., film, 2,700 ohms ±10%, 2 w	DCS-27-034
R313A, B	Res., WW, tapped, two sections, 0.30 ohms ±5%, 11 w/section	DFM-60-050
R315A, B	Same as R313A, B	
R317A, B	Same as R313A, B	
R319	Res., comp., 470 ohms ±10%, 1/2 w	DEB-4711
R324	Res., WW, 500 ohms ±3%, 15 w	DFR-50-071
R326	Not assigned	
R327	Res., comp., 15,000 ohms ±5%, 1 w	DGB-1535
R328	Not assigned	
R330*	Res., meter shunt, 30 amperes	ESP-30-001
R333	Res., WW, 10 ohms ±3%, 3 w	DFP-10-030
SCR301	Rectifier, silicon controlled	FBP-00-008
SCR302	Not assigned	
T1	Transformer	ABA-351-1
T2	Transformer	ABA-351-2

UNIQUE PARTS (Cont)

MODEL LK-351 (Cont)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.
	* This part only used on units with "FM" meter option	
	MODEL LK-352	
C151	Cap., mylar, .068 mf ±10%, 200 vdc	CGL-68-003
C152	Cap., mylar, .10 mf ±10%, 80 vdc	CGM-10-006
C154	Cap., mylar, .0068 mf ±10%, 200 vdc	CGK-68-001
C172	Cap., mylar, .01 mf ±10%, 80 vdc	CGL-10-002
C302	Cap., mylar, 0.1 mf ±10%, 200 vdc	CAM-10-012
C303	Cap., elect., 3000 mf -10 + 100%, 100 vdc	CBS-30-047
C304	Cap., elect., 50 mf -10 + 100%, 80 vdc	CBP-50-026
C305	Cap., elect., 4000 mf -10 + 100%, vdc	CBS-40-053
C306 Thru C309	Same as C305	
C311	Cap., mylar, 1.0 mf ±20%, 200 vdc	CAN-10-024
C312	Not assigned	
C313	Not assigned	
C317	Cap., tant., 10 mf ±20%, 25 vdc	CBP-10-027
CR151	Rectifier, zener diode	FBM-Z118
CR172, CR174	Not assigned	
CR301	Rectifier	FBL-00-083
CR302	Rectifier, zener diode	FBM-Z116
CR305 Thru CR308	Same as CR301	
L301	Reactor, filter	BBA-352
L302	Not assigned	
M1*	Meter, volts, 0-60 vdc	EBP-60-015
M2*	Meter, amperes, 0-20 amps	EDP-20-015
Q171	Transistor, NPN	FBN-L108
Q303	Transistor, NPN	FBN-36487
Q304 Thru Q308	Same as Q303	
R131	Res., comp., 100 ohms ±10%, 1/2 w	DEB-1011
R171	Res., comp., 470,000 ohms ±10%, 1/4 w	DCB-4741
R175	Res., fuse type, WW, 39 ohms ±5%	DLP-39-001
R177	Not assigned	
R301 A, B	Res., var., WW, two sections, 11,800 ohms 200 ohms, ±5%, 5 w/ section	DNT-12-033
R305	Res., comp., 22 ohms ±10%, 1/2 w	DEB-2201
R308	Res., film, 5,600 ohms ±10%, 2 w	DCS-56-033
R313 A, B	Res., WW, tapped, two sections, 0.47 ohms ±5%, 8 w/section	DFM-94-051
R315 A, B	Same as R313A, B	
R317 A, B	Same as R313A, B	

UNIQUE PARTS (Cont)

MODEL LK-352 (Cont)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO
R319	Res., comp., 1,200 ohms ±10%, 1/2 w	DEB-1221
R324	Res., WW, 1,000 ohms ±3%, 15 w	DFS-10-070
R326	Not assigned	
R327	Res., comp., 39,000 ohms ±10%, 1 w	DGB-3931
R328	Res., ww, 3.0 ohms ±3%, 3 w	DFN-30-023
R330	Not assigned	
R333	Res., WW, 10 ohms ±3%, 3 w	DFP-10-030
SCR301	Rectifier, silicon controlled	FBP-00-013
SCR302	Not assigned	
T1	Transformer	ABA-352-1
T2	Transformer	ABA-352-2

* This part only used in units with "FM" meter option.

PARTS FOR "OV" OPTION

The following parts are used only on LK-350 through LK-352 models with "OV" option.

LKOV-B overvoltage subassembly used on all LK-350 through LK-352 models (see separate electrical parts list LKOV-B for components located on this subassembly)

COMMON PARTS

C2	Cap., elect., 10 mf -10 + 100%, 25 vdc	CBP-10-018
C3	Cap., elect., 70 mf -10 + 100%, 90 vdc	CBP-70-012
CR1	Rectifier	FBL-00-030
R72	Res., comp., 3.3 ohms ±10%, 1/2 w	DEB-33G1
R73	Res., WW, 1.0 ohms ±3%, 3 w	DFN-10-041
SCR71	Rectifier, silicon controlled Rectifier	FBP-00-010

UNIQUE PARTS LK -350

CR2	Rectifier	FBL-00-030
R1	Res., var., 10,000 ohms ±10%, 1/2 w	DNT-10-028

UNIQUE PARTS LK-351

CR2	Not assigned	
R1	Res., var., 20,000 ohms 10%, 1/2 w	DNT-20-029

UNIQUE PARTS LK-352

CR2	Not assigned	
R1	Res., var., 30,000 ohms ±10%, 1/2 w	DNT-30-030

LKOV-B SUBASSEMBLY

C1	Cap., mylar, 0.01 mf ±20%, 80 vdc	CGL-10-009
Q1	Transistor, NPN	FBN-L102
Q2	Transistor, PNP	FBN-L114
R2	Res., film, 560 ohms ±2%, 1/2 w	DCR-56-002

UNIQUE PARTS (Cont)

LKOV-B SUBASSEMBLY (Cont)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO
R3	Res., film, 200 ohms ±5%, 1/2 w	DCR-20-010
R4	Res., thermistor, 425 ohms ±5%, 1-1/4 w	DKR-43-004
R5	Res., comp., 1200 ohms ±10% 1/2 w	DEB-1221
R6	Same as R5	
R7	Res., comp., 33 ohms ±5% 1/4 w	DCB-3305
R8	Res., comp., 15,000 ohms ±10%, 1/2 w	DEB-1531
R9	Res., comp., 22 ohms ±10%, 1/2 w	DEB-2201
R10	Same as R5	
SCR1	Rectifier, silicon, controlled	FBP-00-009

PARTS FOR "T" OPTION

LK-350 through LK-352 models with "T" option have the same part changes as listed for "V" option except for transformers listed below.

T1	Transformer	Add suffix "T" to Reg. T1 no.
T2	Transformer	Add suffix "T" to Reg. T2 no.

PARTS FOR "V" OPTION

The following parts change on all LK-350 through LK-352 models

C315	Cap., paper, 0.10 mf ±20% 400 vdc	CAM-10-026
F1	Fuse "SLO-BLO" 15 amps	FFH-15-000
XF1	Fuseholder	HRM-00-007

Transformers T1 and T2 of all LK-350-LK-352 units with "V" option are series connected instead of parallel connected. For these transformers see standard LK-350 through LK-352 parts list for the standard part nos. and add suffix "G" * to the part no.

*Suffix "V" for units with serial no. prefixes A & B.

PARTS FOR THE "R" OPTION

MODELS LK-350 - LK-352

Transformer T1 and T2 change on all LK-350 through LK-352 models with "R" option. For transformers T1 and T2 used in these models see standard LK-350 through LK-352 parts list for the standard transformer part nos. and add suffix "R" to the part nos.

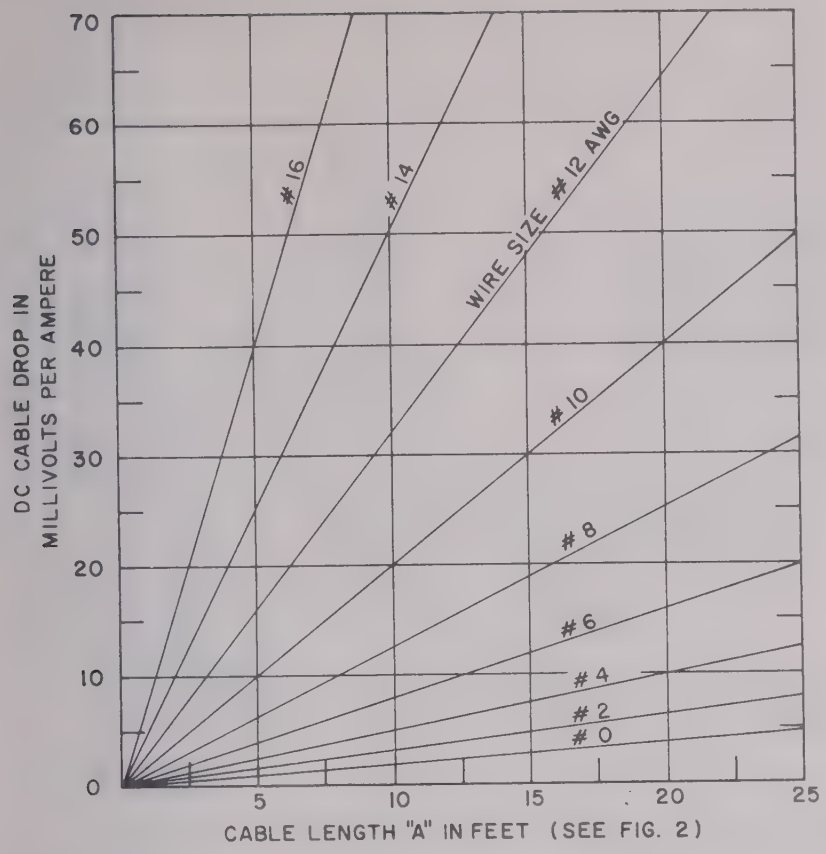


Figure 1. Cable Connection Chart

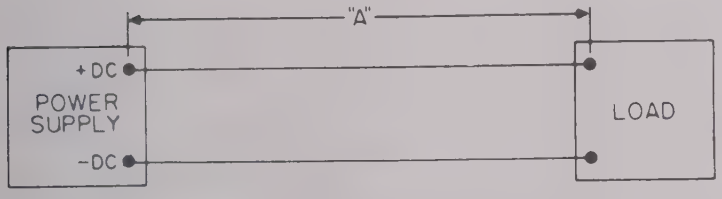
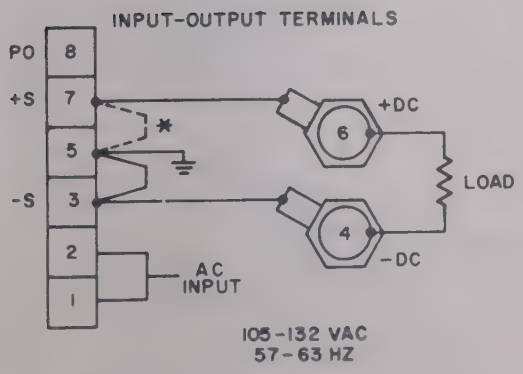
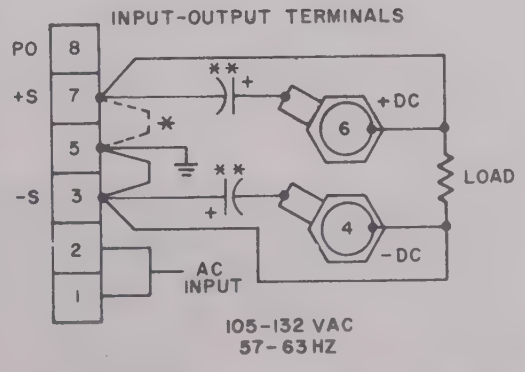


Figure 2. Cable Length "A" in Feet



NOTE:
* FOR POSITIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 3 AND 5 AND RECONNECT TO TERMINALS 5 AND 7.

Figure 3. Two-Wire Connection



NOTE:
* FOR POSITIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 3 AND 5 AND RECONNECT TO TERMINALS 5 AND 7.
** A 2.5MF, ELECT., CAP. MAY BE REQUIRED.

Figure 4. Four-Wire Connection

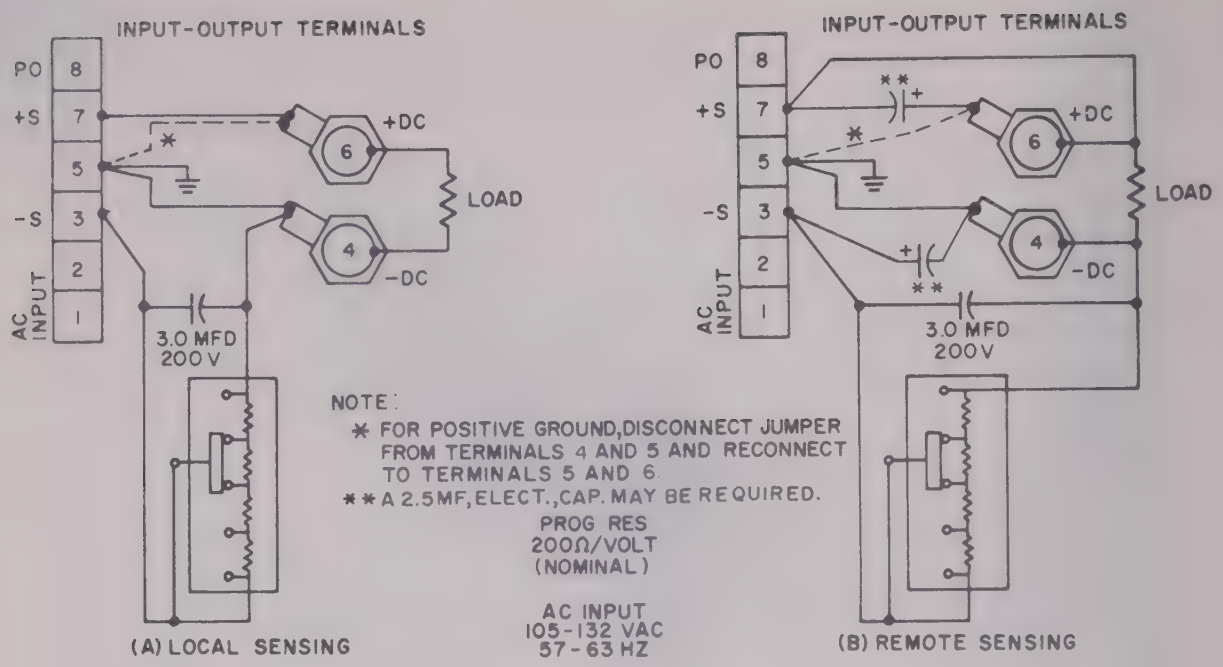


Figure 5. Programmed Voltage, With External Resistor

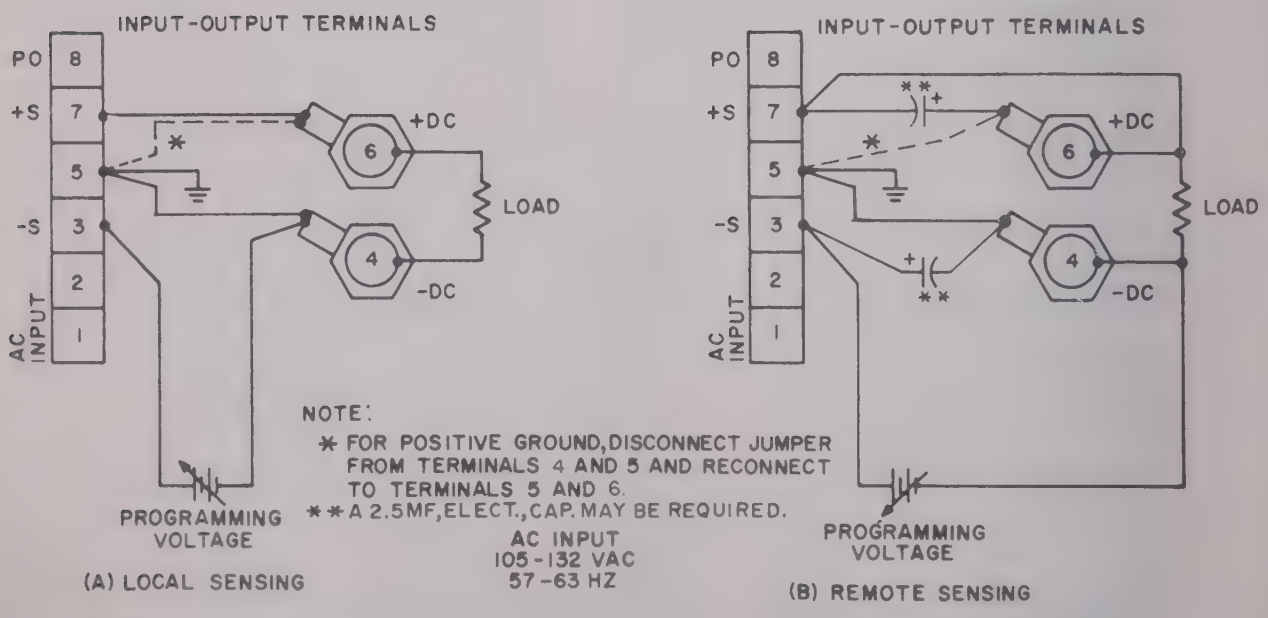
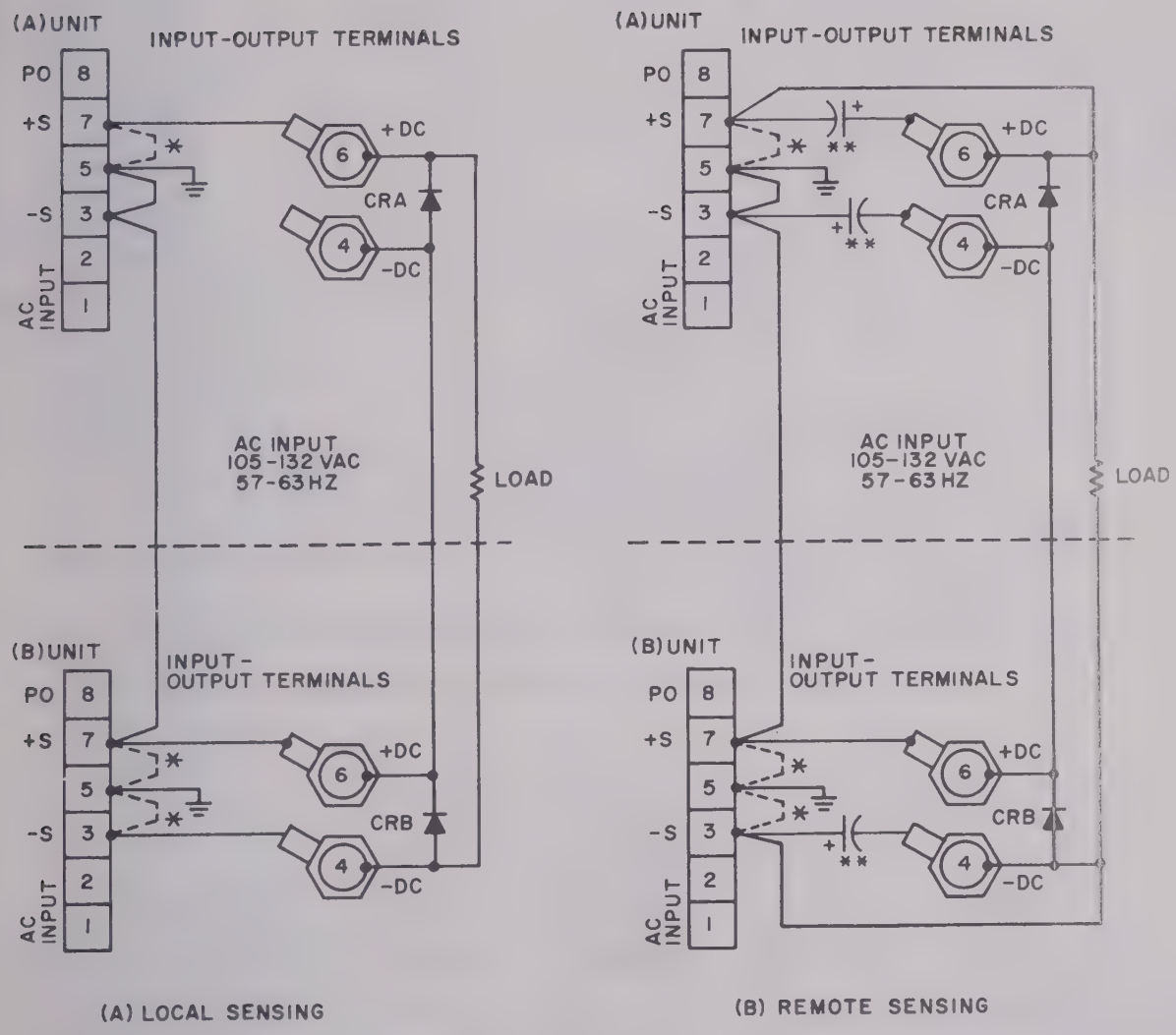


Figure 6. Programmed Voltage With External Programming Voltage Source

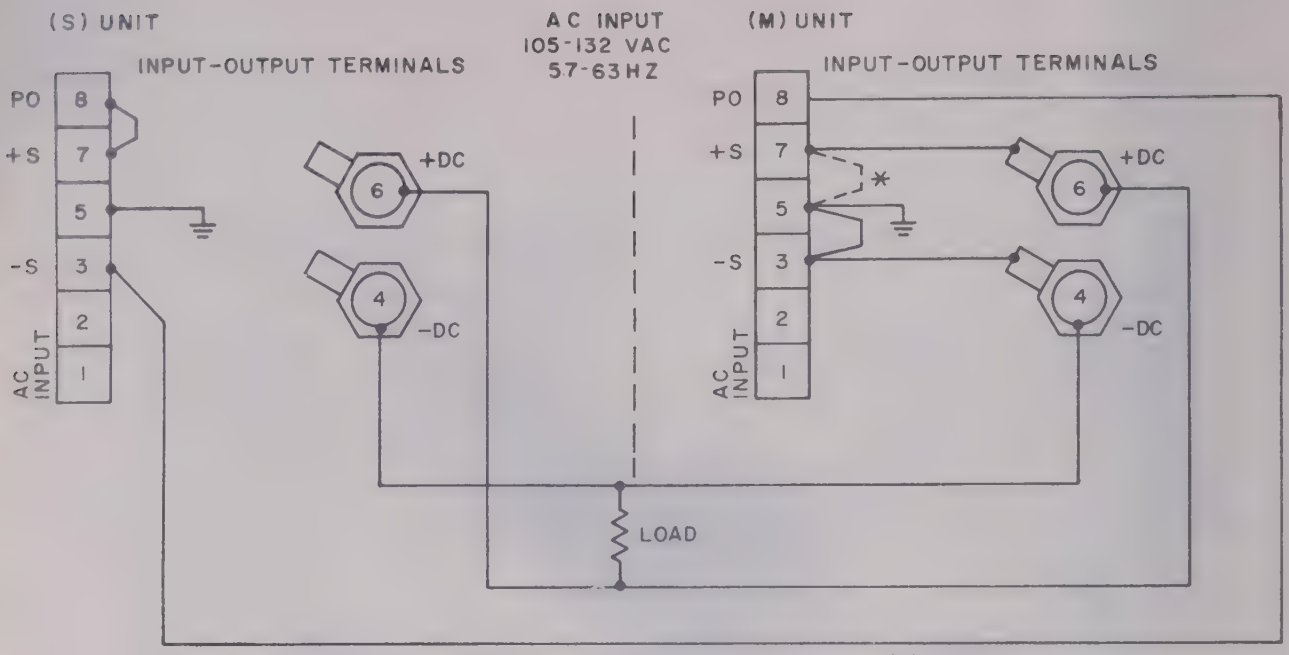


NOTE:

* MAKE ONLY ONE GROUND CONNECTION FOR SERIES COMBINATION. TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM TERMINALS 5 AND 3 ON (A) UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

** A 2.5MF, ELECT., CAP. MAY BE REQUIRED.

Figure 7. Series Connection



NOTE:

* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 3 AND RECONNECT TO TERMINALS 7 AND 5.

* * FOR IMPROVED CURRENT BALANCING, THE "+DC" LEADS MUST BE THE SAME LENGTH AND SIZE.

Figure 8. Parallel Connection, Local Sensing

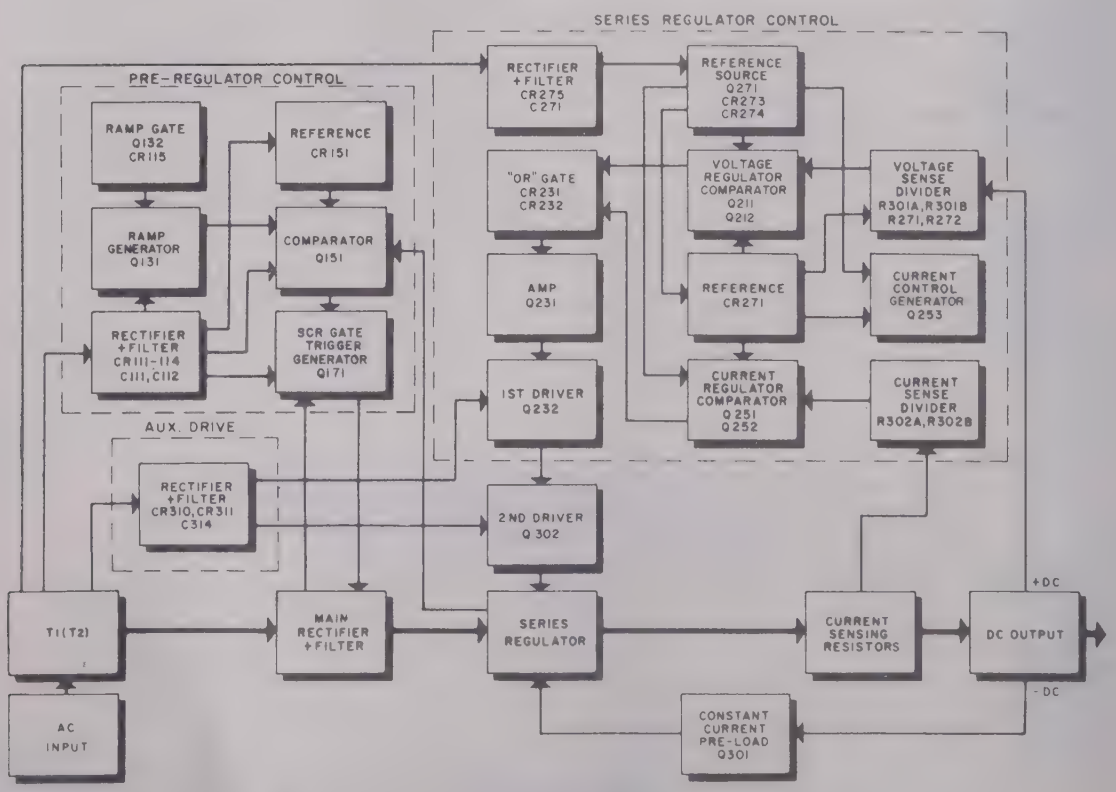
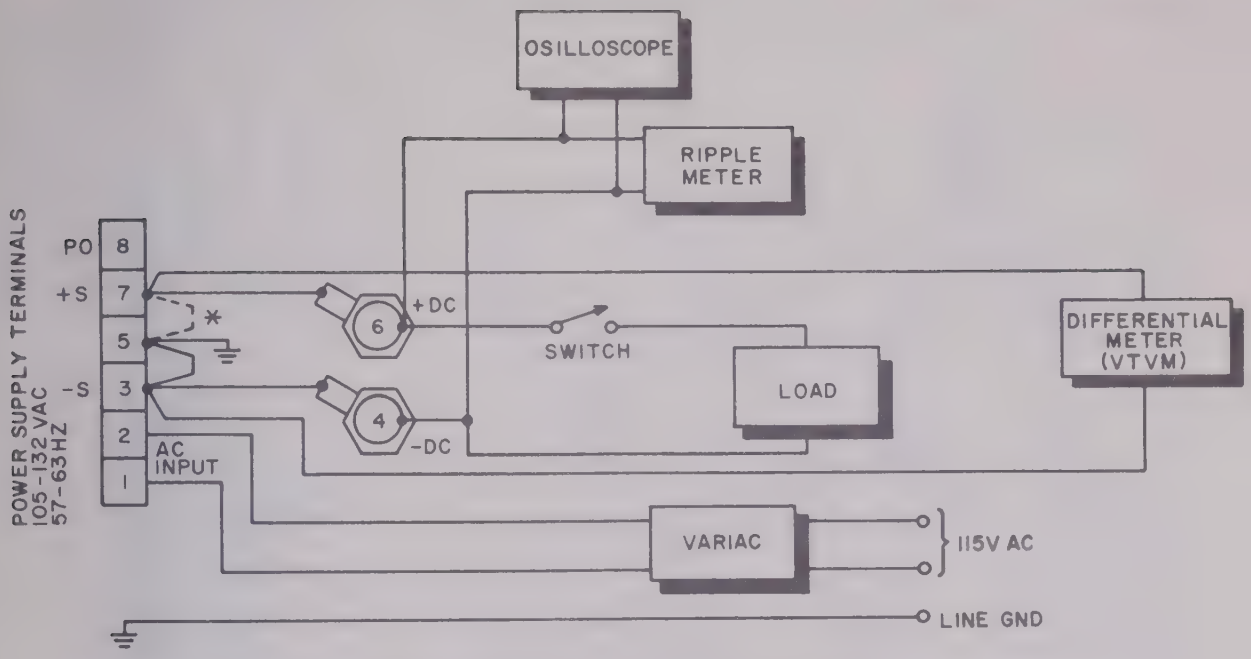
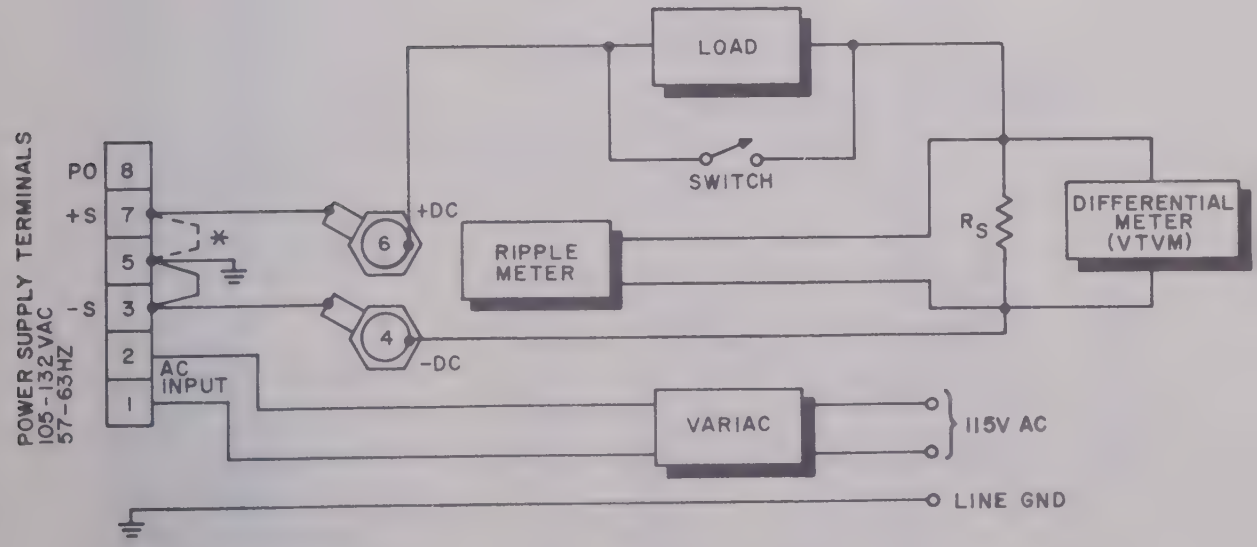


Figure 9. Typical Block Diagram



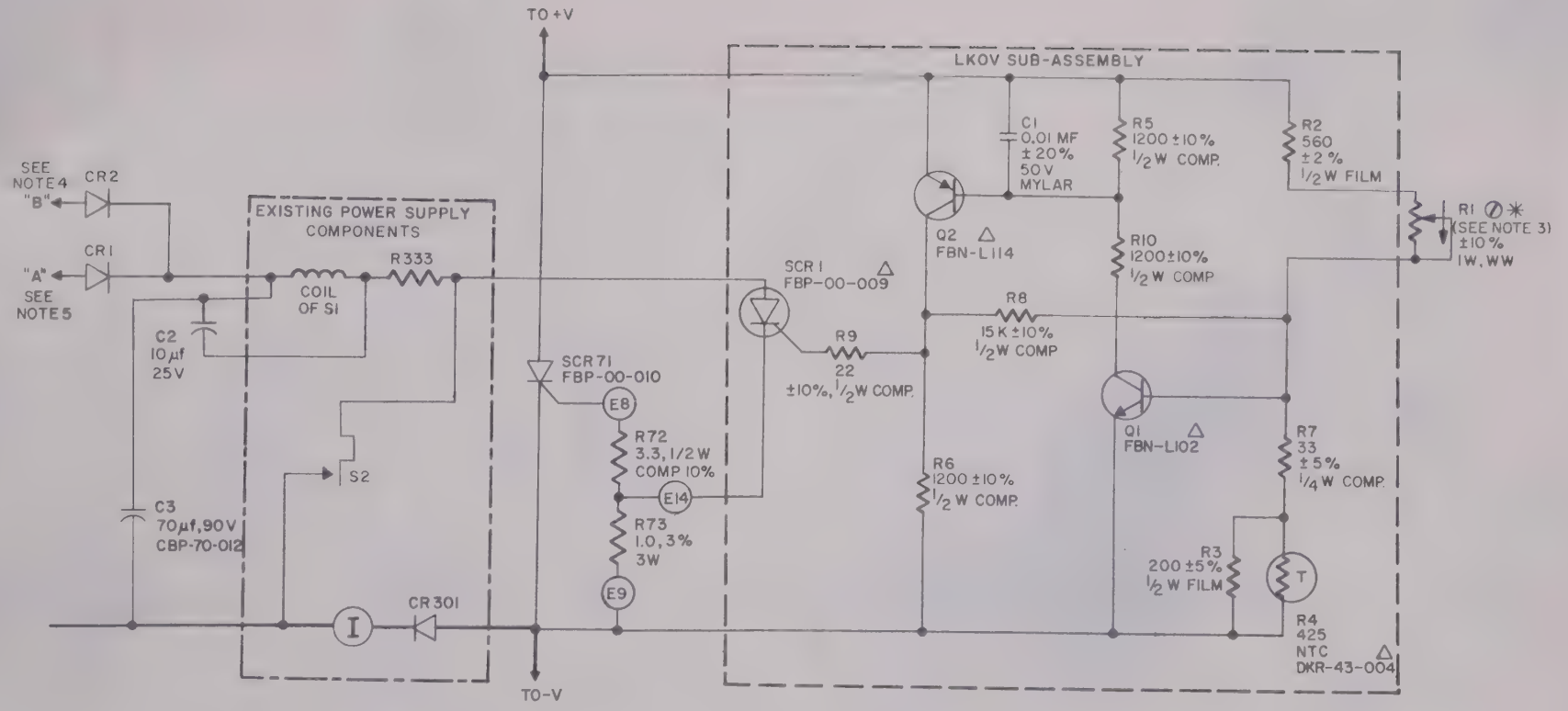
NOTES:
1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

Figure 10. .Test Connections For Constant Voltage Performance Checks



NOTES:
1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

Figure 11. Test Connections For Constant Current Performance Checks



NOTES

1. RESISTOR VALUES ARE IN OHMS.
2. SYMBOLS:
   - ↻ INDICATES CLOCKWISE ROTATION OF SHAFT.
   - ⊘ INDICATES ADJUSTMENT OR CALIBRATION CONTROL.
   - ✳ SEE INSTRUCTION MANUAL.
   - △ LAMBDA PART NUMBER.
3. VALUE OF RESISTOR R1 CHANGES AS FOLLOWS:

MODEL	R1 VALUE
LK350, LK360	10K
LK351, LK361	20K
LK352, LK362	30K

4. POINT "B" AND DIODE CR2 ONLY USED FOR MODELS LK361, LK350 AND LK360. POINT "B" CONNECTS TO TERMINAL "C" OF TRANSFORMER T1 ON THESE UNITS.
5. POINT "A" FROM DIODE CR1 CONNECTS TO THE POWER SUPPLY CIRCUIT AS FOLLOWS:

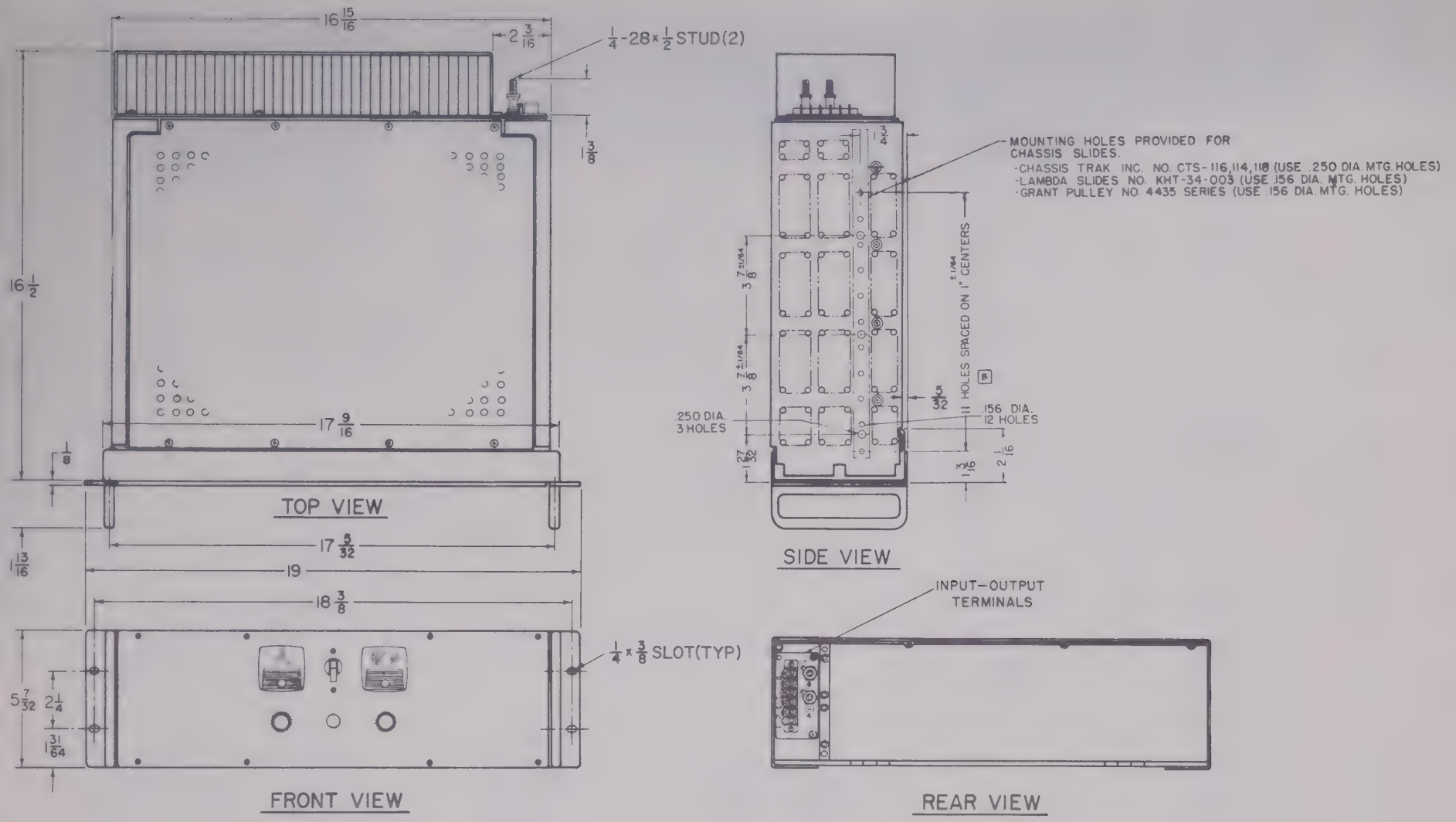
MODEL	P.S. CIRCUIT CONNECTION POINT
LK350, LK360, LK361	TERMINAL "D" OF XFMR T1
LK351, LK352, LK362	CATHODE OF DIODE CR308

THIS SCHEMATIC APPLIES TO UNITS BEARING SERIAL NO. PREFIX A-C

SCHEMATIC DIAGRAM

OVERVOLTAGE PROTECTOR CIRCUIT

LAMBDA
ELECTRONICS
MELVILLE, L.I., N.Y.
DIVISION OF Veeco INSTRUMENTS INC.



Outline Drawing

SCB-350A

NOTES

1 RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE NOTED
2 RESISTOR WATTAGE 1/2 WATT, RESISTORS ABOVE 2 WATTS ARE WIREWOUND UNLESS OTHERWISE NOTED
3 RESISTOR TOLERANCES: COMPOSITION ±10%, WIREWOUND ±5% UNLESS OTHERWISE NOTED
4 CAPACITOR TOLERANCES: ELECTROLYTIC, -10% +100%, TANTALUM, ±20%, PAPER, ±10%, CERAMIC, ±20%, MICA, ±20%, MYLAR, ±10%, UNLESS OTHERWISE NOTED
5 SYMBOLS
- INDICATES CLOCKWISE ROTATION OF SHAFT
- INDICATES CONNECTION TO CHASSIS
- INDICATES ADJUSTMENT OR CALIBRATION CONTROL.
- INDICATES ACTUAL UNIT MARKING.
- INDICATES FRONT-PANEL MOUNTED COMPONENT.
- INDICATES FACTORY ADJUSTMENT, SEE INSTRUCTION MANUAL.
- INDICATES TRANSFORMER LUG TERMINAL.
- THIS DIODE IS LAMBDA PART NO FBL-00-030, CAN BE REPLACED WITH STANDARD TYPE 1N4002 DIODE UNLESS OTHERWISE NOTED.

6 CONDITIONS FOR CIRCUIT POINT VOLTAGE MEASUREMENTS
A CONSTANT VOLTAGE
READ ITALICIZED NUMBERS FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT VOLTAGE OPERATION.
INPUT 120 VAC, 60 HZ.
OUTPUT MAX RATED VOLTAGE, OUTPUT CURRENT ZERO.
B CONSTANT CURRENT
READ NUMBERS IN PARENTHESES FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT CURRENT OPERATION.
INPUT 120 VAC, 60 HZ.
OUTPUT 0 VOLTS, OUTPUT CURRENT MAX RATED CURRENT (SHORT CIRCUIT)
INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED
DC MEASUREMENTS TAKEN WITH 20,000 OHMS/VOLT VOLTMETER BETWEEN +DC (TERM 6) AND INDICATED POINTS UNLESS OTHERWISE NOTED
7 DESIGNATIONS ARE LAMBDA PART NUMBERS
8 INDICATES TERMINAL LOCATED ON TERMINAL BOARD "C", OR PRINTED WIRING BOARDS "A", "B".
9 COAT BOTH SIDES OF MICA WASHER OR ANODIZED ALUMINUM WAFER WITH DOW CORNING NO 340 SILICONE GREASE

CAUTION
NOT AT CHASSIS GROUND POTENTIAL
DO NOT SHORT TO CHASSIS GROUND

NOTE 9
MICA INSULATING WASHER
CHASSIS GROUND
COLLECTOR (CASE) BASE EMITTER
TRANSISTOR, PIN VIEW
Q251, Q252, Q211, Q212 DUAL COMPLEMENTARY TRANSISTOR, PIN VIEW

10. ON UNITS WITH "V" OPTION, T1 AND T2 HAVE TAPPED PRIMARIES, TERM. A OF T1 IS REPLACED BY TERM. V, AND TERM B OF T2 IS REPLACED BY TERM. V. "V" OPTION UNITS CAN BE WIRED FOR 187-242V INPUT (T1 TERM G CONNECTED TO T2 TERM. G AND AC INPUT APPLIED BETWEEN T2 TERM A AND T1 TERM B) OR FOR 205-265V INPUT (T1 TERM. V CONNECTED TO T2 TERM V AND AC INPUT APPLIED BETWEEN T2 TERM A AND T1 TERM B). ON UNIT WITH "V" OPTION, SECONDARY C-D OF T1 IS IN // WITH R-S OF T2 AND R-S OF T1 IS IN // WITH C-D OF T2; C315 IS ±20%, PAPER; F1 IS 15A, 250V. ON SERIAL NO. PREFIXES A & B, "V" OPTION UNITS; T1 AND T2 PRIMARIES ARE NOT TAPPED AND TERMS. ARE A & B. AC INPUT IS 205-265V.

CAUTION
TRANSFORMERS IN NON "V" OPTION UNITS CANNOT BE OPERATED AT 205-265 VAC BY MERELY PUTTING THE PRIMARIES IN SERIES. THE 205-265 VAC REQUIRES A COMPLETELY DIFFERENT TRANSFORMER

11 ON UNITS WITH SERIAL NO. PREFIX A, CONN. FROM R312 TO TERM (6) NOT USED, AND TERM (8) WAS CONN. TO TERM (58).

PRE-REGULATOR CONTROL
RAMP GENERATOR
SCR GATE TRIGGER GENERATOR
SERIES REGULATOR CONTROL
REFERENCE SOURCE
CURRENT CONTROL GENERATOR
CURRENT REGULATOR COMPARATOR
VOLTAGE REGULATOR COMPARATOR
OUTPUT REFERENCE
SERIES REGULATOR VOLTAGE SET
COMPARATOR
CONSTANT CURRENT PRE LOAD
PRE-REGULATOR
SERIES REGULATOR
6 TRANSISTORS Q303 THRU Q308 FBN 36972
3 RESISTORS R315A,B R315A,B R317A,B
6 RESISTORS R312, R314, R316, R318, R320, R322
FOR "FM" MODELS ONLY
TB1 REAR OUTPUT TERMINALS
OUTPUT VOLTAGE VDC

FOR WIRING OF POWER SUPPLY TO LOAD REFER TO POWER SUPPLY-TO-LOAD WIRING DIAGRAMS
DOTTED CONNECTIONS SHOWN ON TB1 INDICATE JUMPERS IN PLACE FOR LOCAL SENSING "2-WIRE CONNECTION"

RATING TABLE	
AMBIENT TEMP	MAX LOAD
40°C	0-35 A
50°C	0-31 A
60°C	0-26 A
71°C	0-20 A

THIS SCHEMATIC APPLIES TO UNITS BEARING SERIAL NO PREFIXES A-C.

SCHEMATIC DIAGRAM REGULATED POWER SUPPLY 0-20 VOLTS
MODEL LK 350

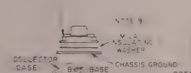
LAMBDA ELECTRONICS MELVILLE, L.I., N.Y.
DIVISION OF Veeco INSTRUMENTS INC

SCB-351-A

NOTES

1. RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE NOTED
2. RESISTOR WATTAGE 1/2 WATT, RESISTORS ABOVE 2 WATTS ARE WIREWOUND UNLESS OTHERWISE NOTED
3. RESISTOR TOLERANCES: COMPOSITION ±10%, WIREWOUND ±5% UNLESS OTHERWISE NOTED
4. CAPACITOR TOLERANCES: ELECTROLYTIC -10% +100%, TANTALUM ±20%, PAPER, ±10%, CERAMIC, ±20%, MICA, ±20%, MYLAR, ±10% UNLESS OTHERWISE NOTED
5. SYMBOLS
   - INDICATES CLOCKWISE ROTATION OF SHAFT
   - INDICATES CONNECTION TO CHASSIS
   - INDICATES ADJUSTMENT OR CALIBRATION CONTROL
   - INDICATES ACTUAL UNIT MARKING
   - INDICATES FRONT-PANEL MOUNTED COMPONENT
   - * INDICATES FACTORY ADJUSTMENT, SEE INSTRUCTION MANUAL
   - INDICATES TRANSFORMER LUG TERMINAL
   - THIS DIODE IS LAMBDA PART NO FBL-00-030, CAN BE REPLACED WITH STANDARD TYPE IN4002 DIODE UNLESS OTHERWISE NOTED
6. CONDITIONS FOR CIRCUIT POINT VOLTAGE MEASUREMENTS
   - A CONSTANT VOLTAGE
     - READ ITALICIZED NUMBERS FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT VOLTAGE OPERATION
     - INPUT 120 VAC, 60 HZ
     - OUTPUT MAX RATED VOLTAGE, OUTPUT CURRENT ZERO
   - B CONSTANT CURRENT
     - READ NUMBERS IN PARENTHESES FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT CURRENT OPERATION
     - INPUT 120 VAC, 60 HZ.
     - OUTPUT 0 VOLTS, OUTPUT CURRENT MAX RATED CURRENT (SHORT CIRCUIT)
   - INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED
   - DC MEASUREMENTS TAKEN WITH 20,000 OHMS/VOLT VOLTMETER BETWEEN +DC (TERM 6) AND INDICATED POINTS UNLESS OTHERWISE NOTED
7. DESIGNATIONS ARE LAMBDA PART NUMBERS
8. ◯ INDICATES TERMINAL LOCATED ON TERMINAL BOARD "C", OR PRINTED WIRING BOARDS "A", "B".
9. COAT BOTH SIDES OF MICA WASHER OR ANODIZED ALUMINUM WAFER WITH DOW CORNING NO 340 SILICONE GREASE

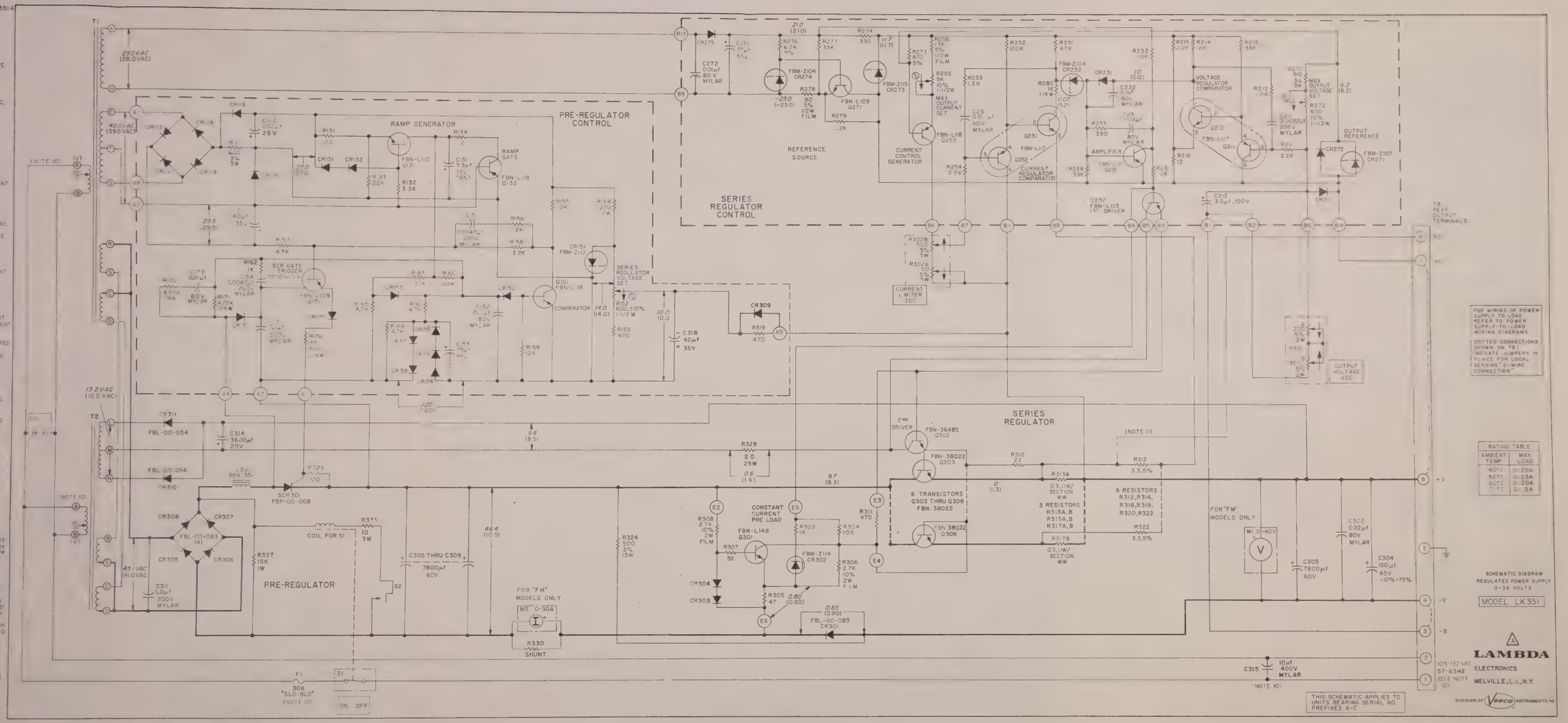
CAUTION
NOT AT CHASSIS GROUND POTENTIAL
DO NOT SHORT TO CHASSIS GROUND



10. ON UNITS WITH "V" OPTION, T1 AND T2 HAVE TAPPED PRIMARIES; TERM A OF T1 IS REPLACED BY TERM. V, AND TERM. B OF T2 IS REPLACED BY TERM. V. "V" OPTION UNITS CAN BE WIRED FOR 187-242V INPUT (T1 TERM G CONNECTED TO T2 TERM. G AND AC INPUT APPLIED BETWEEN T2 TERM. A AND T1 TERM B). OR FOR 205-265V INPUT (T1 TERM V CONNECTED TO T2 TERM V AND AC INPUT APPLIED BETWEEN T2 TERM A AND T1 TERM. B). ON UNIT WITH "V" OPTION, SECONDARY C-D OF T1 IS IN // WITH R-S OF T2 AND R-S OF T1 IS IN // WITH C-D OF T2; C315 IS ±20% PAPER, F1 IS 15A, 250V ON SERIAL NO. PREFIXES A&B, "V" OPTION UNITS. T1 AND T2 PRIMARIES ARE NOT TAPPED AND TERMS. ARE A&B. AC INPUT IS 205-265V

CAUTION
TRANSFORMERS IN NON "V" OPTION UNITS CANNOT BE OPERATED AT 205-265 VAC BY MERELY PUTTING THE PRIMARIES IN SERIES. THE 205-265 VAC REQUIRES A COMPLETELY DIFFERENT TRANSFORMER.

11. ON UNITS WITH SERIAL NO. PREFIX A, CONN FROM R312 TO TERM ⑧ NOT USED, AND TERM ⑧ WAS CONN TO TERM ⑩.



SCB-352A

NOTES:

1. RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE NOTED.
2. RESISTOR WATTAGE 1/2 WATT, RESISTORS ABOVE 2 WATTS ARE WIREWOUND UNLESS OTHERWISE NOTED.
3. RESISTOR TOLERANCES: COMPOSITION ±10%, WIREWOUND ±5% UNLESS OTHERWISE NOTED.
4. CAPACITOR TOLERANCES: ELECTROLYTIC -10% +100%, TANTALUM, ±20%, PAPER, ±10%, CERAMIC, ±20%, MICA, ±20%, MYLAR, ±10%, UNLESS OTHERWISE NOTED.
5. SYMBOLS
   - INDICATES CLOCKWISE ROTATION OF SHAFT.
   - INDICATES CONNECTION TO CHASSIS.
   - INDICATES ADJUSTMENT OR CALIBRATION CONTROL.
   - INDICATES ACTUAL UNIT MARKING.
   - INDICATES FRONT-PANEL MOUNTED COMPONENT.
   - INDICATES FACTORY ADJUSTMENT, SEE INSTRUCTION MANUAL.
   - INDICATES TRANSFORMER LUG TERMINAL.
   - THIS DIODE IS LAMBDA PART NO. FBL-00-030, CAN BE REPLACED WITH STANDARD TYPE IN4002 DIODE UNLESS OTHERWISE NOTED.
6. CONDITIONS FOR CIRCUIT POINT VOLTAGE MEASUREMENTS:
   A. CONSTANT VOLTAGE
      READ ITALICIZED NUMBERS FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT VOLTAGE OPERATION.
      INPUT: 120 VAC, 60 HZ.
      OUTPUT: MAX RATED VOLTAGE, OUTPUT CURRENT ZERO.
   B. CONSTANT CURRENT
      READ NUMBERS IN PARENTHESES FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT CURRENT OPERATION.
      INPUT: 120 VAC, 60 HZ.
      OUTPUT: 0 VOLTS, OUTPUT CURRENT MAX RATED CURRENT (SHORT CIRCUIT).
   INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED.
   DC MEASUREMENTS TAKEN WITH 20,000 OHMS/VOLT VOLTMETER BETWEEN +DC (TERM 6) AND INDICATED POINTS UNLESS OTHERWISE NOTED.
7. DESIGNATIONS ARE LAMBDA PART NUMBERS.
8. ◯ INDICATES TERMINAL LOCATED ON TERMINAL BOARD "C", OR PRINTED WIRING BOARDS "A", "B".
9. COAT BOTH SIDES OF MICA WASHER OR ANODIZED ALUMINUM WAFER WITH DOW CORNING NO. 340 SILICONE GREASE.

CAUTION
NOT AT CHASSIS GROUND POTENTIAL
DO NOT SHORT TO CHASSIS GROUND

NOTE 9
MICA INSULATING WASHER
CHASSIS GROUND

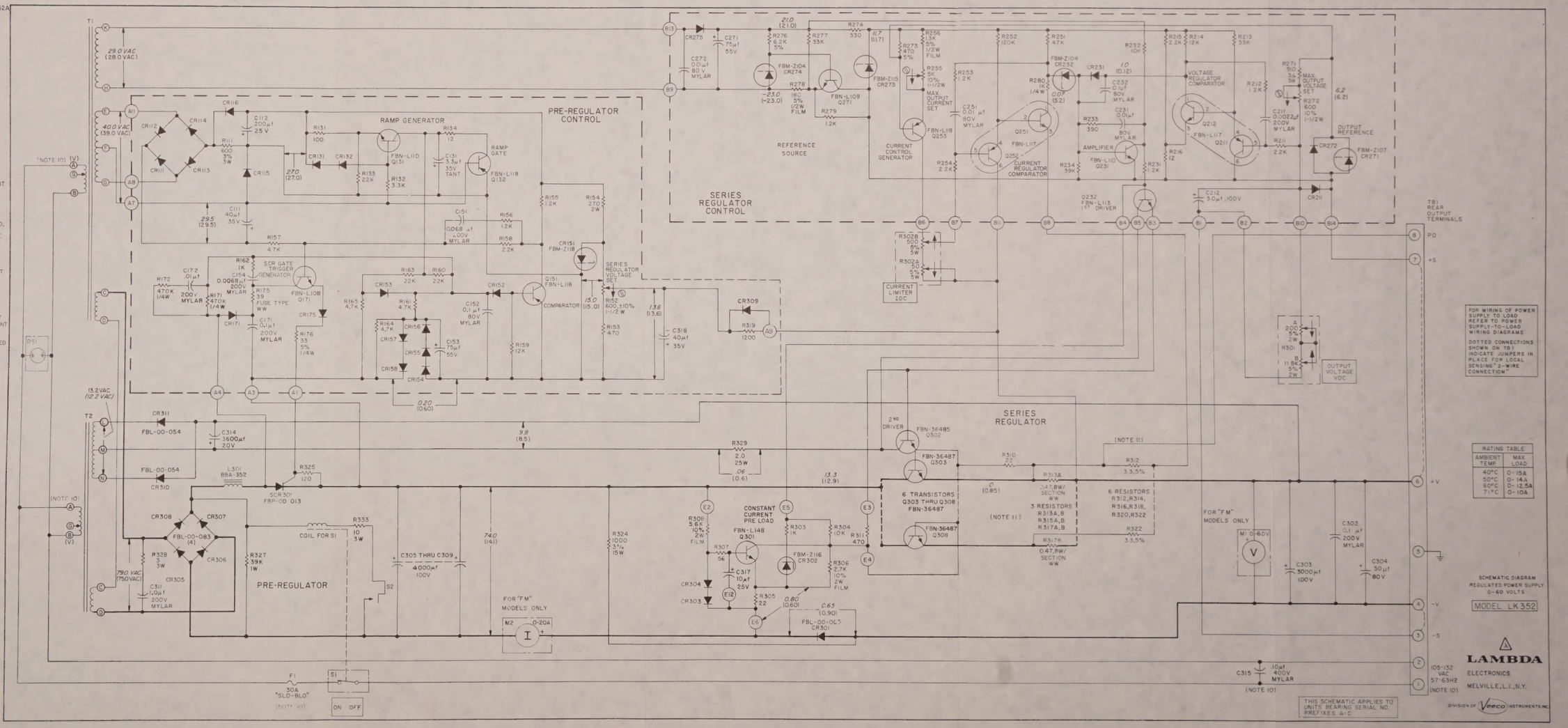
COLLECTOR (CASE) — BASE — EMITTER
TRANSISTOR, PIN VIEW

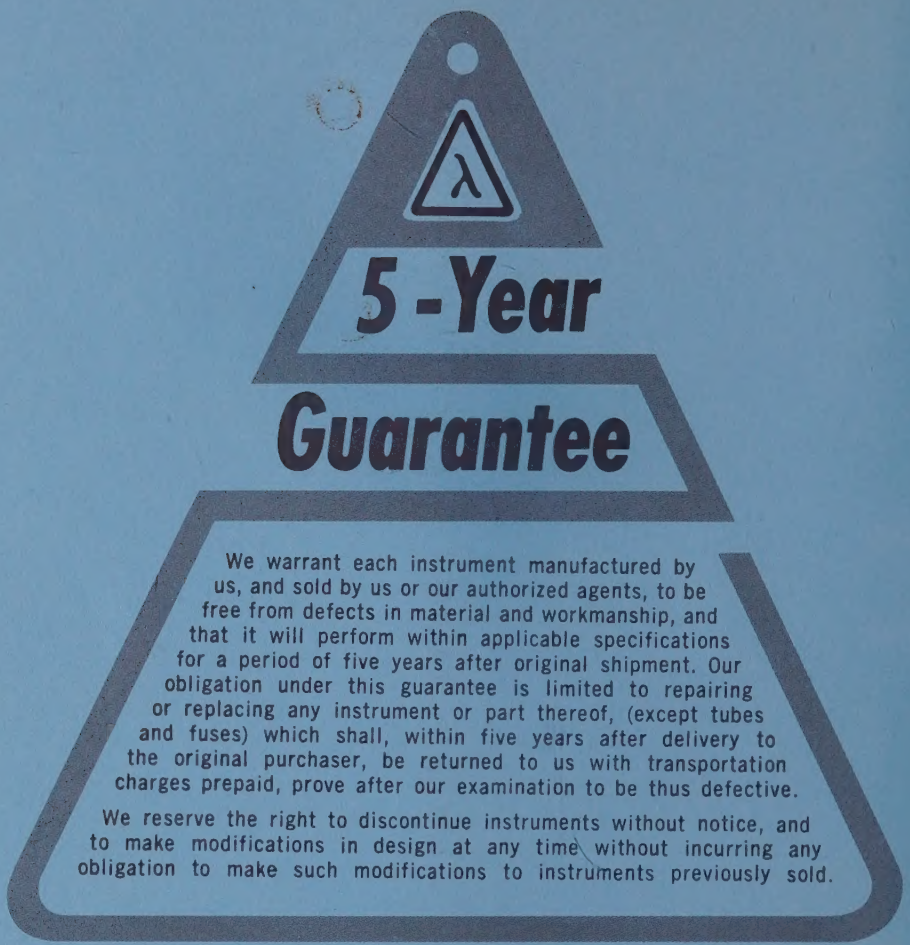
Q251, Q252, Q211, Q212
DUAL COMPLEMENTARY TRANSISTOR, PIN VIEW

10. ON UNITS WITH "V" OPTION, T1 AND T2 HAVE TAPPED PRIMARIES; TERM. A OF T1 IS REPLACED BY TERM. V, AND TERM. B OF T2 IS REPLACED BY TERM. V. "V" OPTION UNITS CAN BE WIRED FOR 187-242V INPUT (T1 TERM. G CONNECTED TO T2 TERM. G AND AC INPUT APPLIED BETWEEN T2 TERM. A AND T1 TERM. B) OR FOR 205-265V INPUT (T1 TERM. V CONNECTED TO T2 TERM. V AND AC INPUT APPLIED BETWEEN T2 TERM. A AND T1 TERM. B). ON UNIT WITH "V" OPTION, SECONDARY C-D OF T1 IS IN // WITH C-D OF T2; C315 IS ±20% PAPER, F1 IS 15A, 250V. ON SERIAL NO. PREFIXES A&B, "V" OPTION UNITS; T1 AND T2 PRIMARIES ARE NOT TAPPED AND TERMS. ARE A&B. AC INPUT IS 205-265V.

CAUTION
TRANSFORMERS IN NON "V" OPTION UNITS CANNOT BE OPERATED AT 205-265 VAC BY MERELY PUTTING THE PRIMARIES IN SERIES, THE 205-265 VAC REQUIRES A COMPLETELY DIFFERENT TRANSFORMER.

11. ON UNITS WITH SERIAL NO. PREFIX A, CONN. FROM R312 TO TERM. Ⓑ NOT USED, AND TERM Ⓑ WAS CONN TO TERM. (BB). RESISTORS R313A,B R315A,B AND R317A,B WERE 0.3, 1W/SECTION.




5-Year
Guarantee
We warrant each instrument manufactured by us, and sold by us or our authorized agents, to be free from defects in material and workmanship, and that it will perform within applicable specifications for a period of five years after original shipment. Our obligation under this guarantee is limited to repairing or replacing any instrument or part thereof, (except tubes and fuses) which shall, within five years after delivery to the original purchaser, be returned to us with transportation charges prepaid, prove after our examination to be thus defective.
We reserve the right to discontinue instruments without notice, and to make modifications in design at any time without incurring any obligation to make such modifications to instruments previously sold.

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